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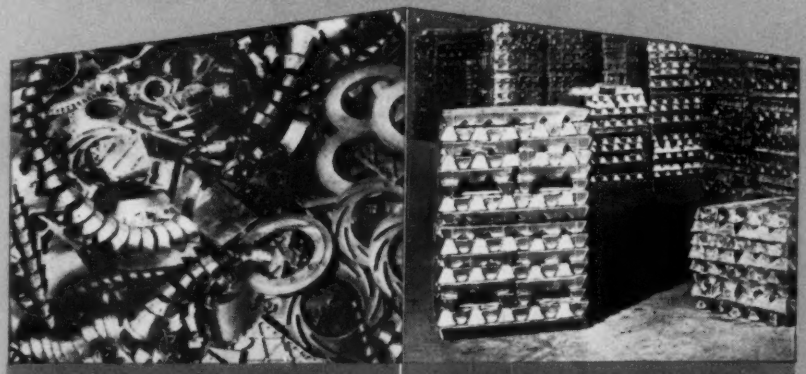

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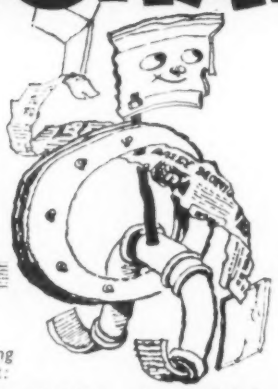

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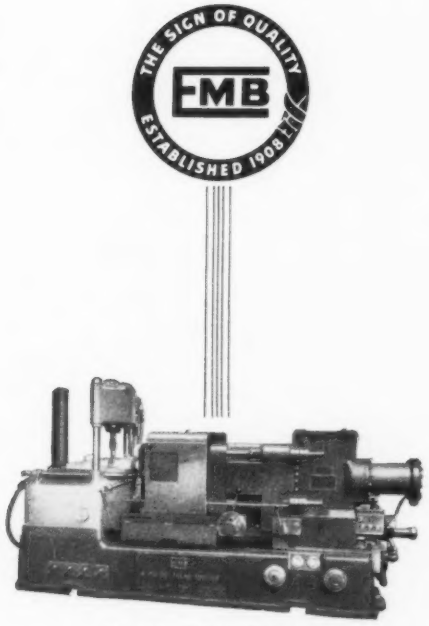

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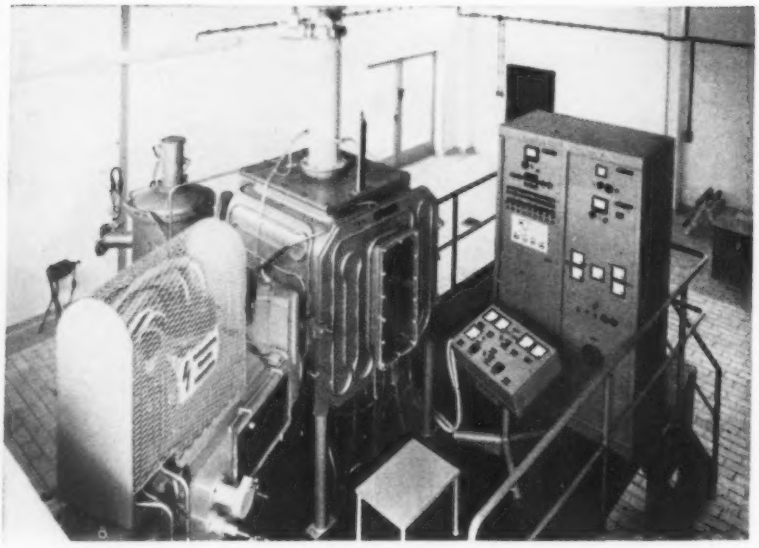

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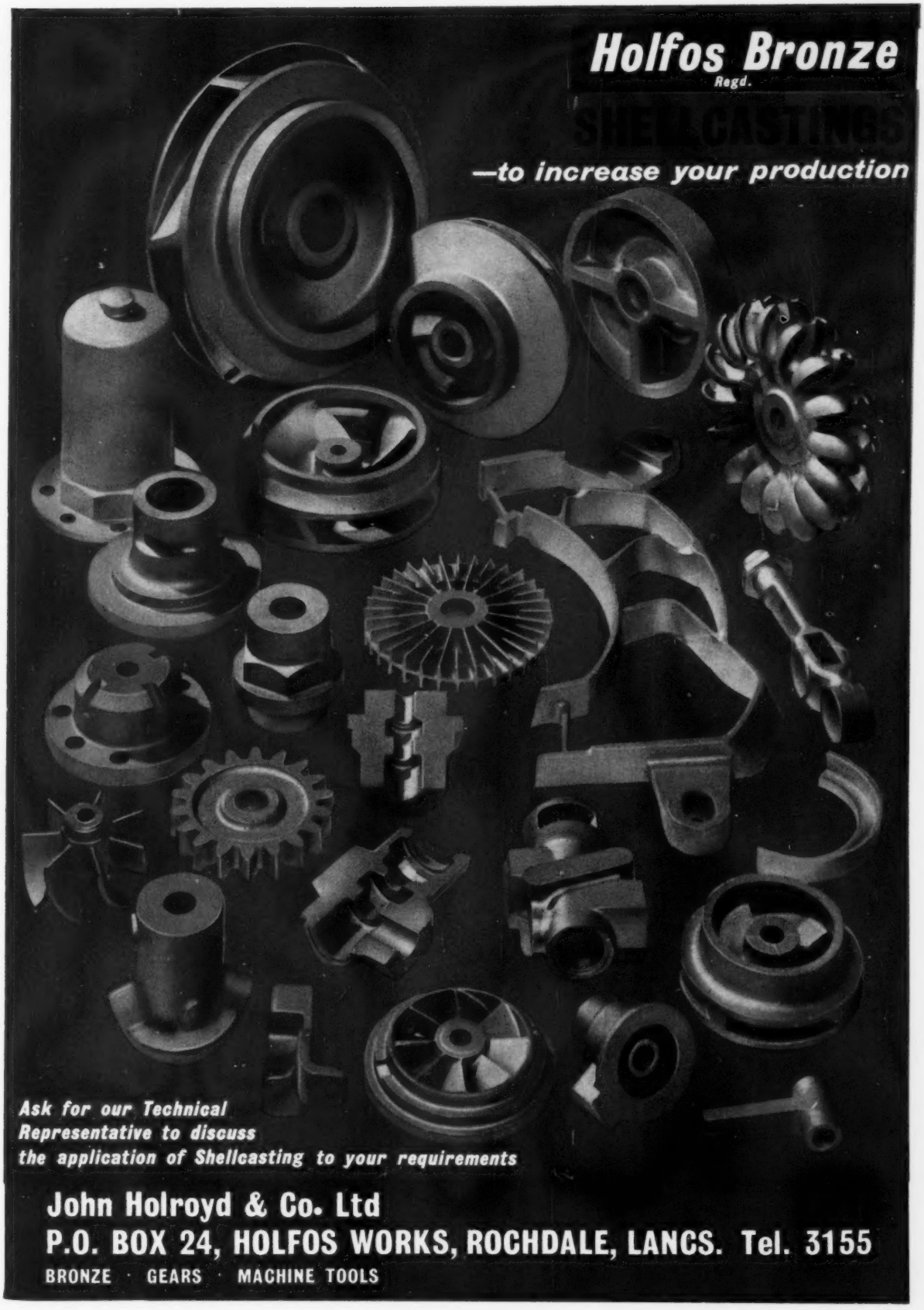
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In some cases the existing procedure of a producer is accepted as the best practice of the art and is taken as a basis for the standard in question. Thus British Standard 1004 (Zinc Alloy for Die Casting) was based on the established practice of the Imperial Smelting Corporation in the production of Mazak.

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METAL INDUSTRY

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The Future of Copper

NO major basic materials industry has a better record of research and development on the production and processing side than the copper industry. What other major metal, for instance, is regularly recovered from ores running less than one per cent metal? In fact, it can be said that it is the technological developments on the exploration, mining and processing side of the copper industry that have created the present excess capacity. Unfortunately, up to the present, the other side of the picture—the development of new and original products—has been by no means so attractive. While it is true that the characteristics of copper have been well investigated, and that certain of its properties make the development of new applications difficult, it is also true that some copper technologists have too long suffered from a "can't-be-done" complex.

That "the wind of change" is blowing through the industry is evidenced by the fact that there are now a number of copper products developed or in an advanced stage of development that presumably were extremely difficult of accomplishment. One, for instance, is a soft copper foil, only four microns thick, produced by cold rolling. Another is a foil-over-asphalt roofing shingle which solves the problem of unattractive "dishing" in a plane surface by the simple expedient of forgetting the need for a perfect plane and imprinting an artistic texture into the material. There is also a method of seam-butt welding of copper with an oxygen lance without oxidation, and a technique for pre-applying a patina finish to copper without resort to electrolysis.

The "wind" is shortly scheduled to become a "hurricane". The copper industry now has a single goal, namely, the increased use of copper through every known means, including research and development, applications engineering, promotion and public relations. Spearhead of the attack is the Copper Products Development Association, which is co-operating with the copper development centres in Europe, Southern Rhodesia, Canada, Australia, the United States and elsewhere for integrated efforts on the whole copper product promotion front. Each unit within the total effort will contribute the function for which it is best suited. In effect, copper markets will be created through the development of new products by the C.P.D.A., or under its co-ordination and supervision, through the dissemination of information about these products by the copper development centres scattered throughout the world, and finally through the exploitation of such information by individual companies.

The Association, made up of 34 copper-producing companies together accounting for more than 90 per cent of the Free World's copper production, has at present some thirteen research projects in progress. The present projects are concerned with the development of tarnish-resistant copper products through the formation of thin oxide films over the fabricated metal, and the development of thermally conductive but electrically insulating copper-containing materials. Copper-based fuel additives to catalyze more completely oxidation of fuels in internal combustion engines, and new types of building products are also under investigation. Several of the studies are of a fundamental nature, designed to open up new paths to product development. In addition, the Association is sponsoring engineering applications projects, such as a programme to assist iron foundries in the techniques for using copper as a minor alloying element in cast iron. With the avowed object, according to Dr. C. H. Moore, its technical director, of selling copper in any form, there is no doubt that the Association will have a predominating influence on the future of copper. Provided its researches bear fruit, present surplus capacities should soon be absorbed.

Out of the MELTING POT

More Complicated

BIMETALLIC sheets, clad sheets and the like have been in production for a good many years now. They comprise two or more layers of different metals and/or alloys bonded together. Their manufacture is relatively simple. Slabs, plates or sheets of the required metals of the required relative thickness are selected, the surfaces over which bonding is to take place are cleaned, the metals are assembled, the assembly is fastened together by tack welds or other means, heated to a suitable temperature and then hot rolled and subsequently cold rolled if necessary. The existence of a simple and successful process of doing something has, however, never succeeded in stopping inventors from thinking up a more elaborate way of achieving the same purpose. Thus, in the case of the above method of producing composite metal products, an improved method of solid phase bonding malleable metal components has now been devised which comprises "the successive steps of removing gross contaminants from the faces to be bonded, heating them to remove surface films which would otherwise act as barriers to bonding, subjecting the components to reduction means to effect a partial bond between the components, utilizing means to preserve said partial bond, and then subjecting the so bonded components to further reduction means to effect an improved bond sufficient to prevent separation of the components, and finally sintering to form a permanent bond between the contacting faces of the components". In putting this invention into practice, the component strips to be bonded, after suitable preparation, are rolled in a single pass to produce a partial bond, reheated if necessary, and then rerolled in one or two more passes to increase the amount of bonding. The degree of bonding is then increased still further to the required degree by sintering the composite material without any further rolling. To give the inventors their due, the advantage of this method over the conventional technique is that bonding is completed by sintering, and the amount of rolling and deformation required is therefore reduced to a minimum. This can be helpful, particularly when producing wide composite strip, where the conventional procedure would require the use of very heavy mills to effect the necessary deformation for the purpose of forming the bond.

Adhesion Test

APART from their immediate purpose of determining the ability of sheet metal to undergo deep drawing, the Erichsen and similar cupping tests, in which a blank held between a draw ring and a pressure plate is drawn by a spherical-ended punch, have also been adapted to test the ductility and/or adhesion of coatings applied to sheet metal. A particularly useful application of the latter kind is for the determination of the adhesion of vitreous enamel coatings. Alternative methods, in which specimens are subjected to impact by a steel ball, are less reliable. If the cupping test is used, failure of the enamel by cracking or flaking can be detected electrically. A reliable way of doing this is by providing a liquid contact to the drawn, concave, surface of the specimen. The liquid—a 10 per cent solution of sodium chloride in water is satisfactory—is contained in a cylindrical vessel suitably mounted on the cupping machine to provide a liquid-tight joint, with the specimen being arranged to close one end of the vessel. The other end is closed by a cover carrying a carbon electrode mounted in an insulating bushing. Insulation must also be provided between the specimen and the vessel containing the salt solution. An A.C. voltage of about 2·5 V is applied between the basis metal of the specimen and the carbon electrode. Failure of the enamel coating as the specimen is drawn is detected by the flow of current between the specimen and the carbon electrode through the damaged enamel coating. If this current is measured (by a milliameter) it can be used to calculate the total surface area of the basis metal exposed by the failure of the enamel, if the specific electrical resistivity of the salt solution, the thickness of the enamel coating, the applied voltage and the external resistance of the circuit are known. The test has been found to give satisfactory results.

Inspiring

PUBLICATION of the results of some given investigation is usually regarded as serving two main purposes: conveying the information to anybody who might be interested, and saving others the trouble of carrying out the same investigation. It may also serve other purposes. Occasionally the original investigation and the results obtained may be found to be so frustratingly restricted in scope and the interpretation given to the results so limited and uncertain, that somebody might, in desperation, be moved to do better: to undertake a wider investigation of the same problem. An example of a frustrating and inspiring investigation of this kind is provided by a study of the effect of plastic deformation on the electrical resistivity of composite silver-alumina alloys. Without branching off on a discussion on whether silver-alumina compositions can properly be called alloys, one can pass on to the first disappointment experienced on reading beyond the title and learning that the silver-alumina alloys investigated were, in fact, a single composition containing about 2 per cent finely divided alumina. It is interesting to note, in passing, that the preparation of the material, starting from a mixture of silver oxide and alumina, followed by reduction of the silver oxide by heating, cold compacting of the mixture, and extrusion at 600°C., involved the ball milling of a slurry of the mixed oxides for about a week. The disappointment arises on learning that the electrical resistivity of the composition was measured at 78°K (liquid nitrogen) in the course of step-wise elongation of the specimen to fracture. Elongation was accompanied by an increase in resistivity, about 33 per cent of which annealed out at room temperature. The disappointment increases on finding that the few results obtained in this way are immediately put to use to derive an exponential expression for the increase in resistivity with elongation. Proceeding still further, the somewhat uncertain and variable "constants" in this expression are then used as evidence of the dislocation mechanism in this dispersion hardened material. Nothing daunted, the changes in the "constants" are in turn ascribed to unascertained (because of analytical difficulties) but presumed variations in the concentration of alumina. All this should be enough to inspire somebody to do better.

Skimmer

Aluminium Alloys For Deep Drawing

By C. J. SMITH A.I.M.
(Technical Director, Birmetals Ltd.)

Prototype all-aluminium saloon car body in Birmabright BB3 [Courtesy Rover Co. Ltd.

AS the degree of ductility and the rate of work hardening differ from alloy to alloy, the selection of aluminium materials for pressing requires careful consideration in relation to these and other properties.

A suitable choice of alloy can usually be made which will give a satisfactory compromise between the requirements of the presswork manufacturer, the metal finisher and the user.

Grades of Pure Aluminium. Various grades of unalloyed aluminium from 99·99 per cent to 99 per cent purity are available, covered by the categories B.S.1470, S1, S1A, S1B and S1C. The higher purity materials of 99·8 per cent and over find special applications in the chemical and food industries, where their high resistance to attack is particularly attractive. The strength, however, is quite low. Even in the fully worked areas of a pressing, tensile strengths of 7-9 tons/in^2 only are attainable, although the generous elongation values, by light alloy standards, of 35-50 per cent enable stretch-forming and pressing of a wide variety of articles to be carried out. Indeed, the S1B and S1C grades are used for many household goods where special chemical resistance is not the main criterion.

The comparative freedom of the higher purity materials from insoluble second-phase constituents renders them particularly suitable for chemical and electrolytic brightening and anodizing treatments whereby a high degree of uniformity of finish and lustre can be obtained.[1]

As the metal purity decreases, structural markings may become apparent during chemical treatments and result from the presence of increasing amounts of the impurity elements, especially iron, silicon and manganese. Below the S1C grade, stringers of these constituents may be formed in the finished sheet and render it liable to significant directional properties which affect formability.

Aluminium-Manganese Alloys. The principal representative of this group in British Standards is the alloy NS3, having a nominal composition aluminium + 1¼ per cent manganese. Some solution hardening takes place as a result of the addition of manganese, and the response to work hardening is also somewhat improved. In the commercial alloy, a small proportion of the manganese is usually present as a second-phase. This, however, rarely gives directionality to mechanical properties but a completely striation-free appearance after chemical or electro-chemical processing is not necessarily guaranteed unless special precautions are taken during the production process.

TABLE I—TYPICAL MECHANICAL PROPERTIES OF THE ALUMINIUM-MAGNESIUM ALLOYS

Alloy	Condition	0·1 per cent P.S. tons/in^2	U.T.S. tons/in^2	Elongation (per cent)	V.D.H.	Brinell Hardness
Al—1 per cent Mg	Soft	3·5	8·0	30	37	36
	¼ Hard	7·0	11·3	14	46	44
	½ Hard	9·0	12·8	8	50	47
	Hard	12·5	15·2	5	63	58
Al—2 per cent Mg (NS4)	Soft	5·0	11·5	23	48	45
	¼ Hard	11·8	13·8	9	60	55
	½ Hard	13·6	16·2	6	72	68
	Hard	16·8	19·0	4	88	84
Al—3·5 per cent Mg (NS5)	Soft	7·0	15·0	25	60	56
	¼ Hard	13·8	17·5	11	80	76
	½ Hard	15·5	19·0	8	90	85
	Hard	18·7	22·4	5	105	100
Al—5 per cent Mg (NS6)	Soft	8·2	18·2	28	75	72
	¼ Hard	16·0	20·3	13	95	91
	½ Hard	18·1	22·5	8	105	100
Al—7 per cent Mg (NS7)	Soft	10·5	21·5	22	105	100

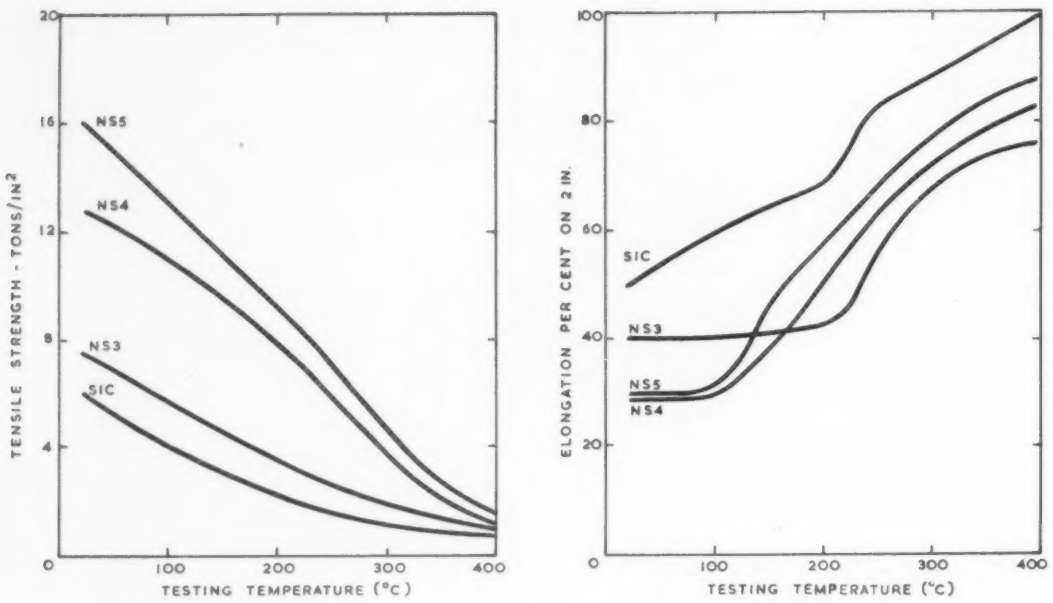

Fig 1—Graphs showing relationship between temperature and mechanical properties of some light alloys

As a pressing alloy it enjoys wide popularity for pots and pans and other domestic holloware for, compared with pure aluminium, it usually enables lower gauges of metal to be used while gaining equal or even slightly better strength. Shallow trays and rectangular containers for many trades are made in this material.

On the Continent and in the U.S.A., an attempt has been made to strengthen the alloy by adding approximately 0·5 to 1·0 per cent of magnesium. The properties appear, at first sight, attractive, but it is the opinion in certain quarters that somewhat more noticeable directionality effects result.

This is particularly to be noted in bending "with the grain"; furthermore, the anodizing characteristics are certainly not improved and it is, perhaps, for these reasons that this variant of the alloy has not hitherto proved popular in this country.

Aluminium - Magnesium Alloys. These alloys are covered by the designations NS4, NS5, NS6 and NS7. They contain increasing percentages of magnesium as the main alloying element and this confers, as will be seen from Table I, appreciable solid solution hardening and an enhanced rate of work hardening which increases as the magnesium content rises. It will be noted from the typical values given in Table I that in the soft condition all alloys have elongation values greater than 20 per cent, and in some cases over 25 per cent.

This group provides the most useful series of current alloys for deep drawing and pressing. The precise choice of magnesium content is largely determined by personal experience and economics, for although the higher magnesium alloys develop stronger pressings they are more difficult and expensive to produce. Indeed, for very deep draws, the need for inter-stage annealing of, say, NS6 material, in some cases makes it economically unattractive as compared to NS5, in which it may not necessarily be possible to develop an equivalent component strength.

The usual choice is NS4 or NS5. One of these two alloys in an appropriate gauge and temper has been found to fulfil the demands of several British motor car manufacturers for

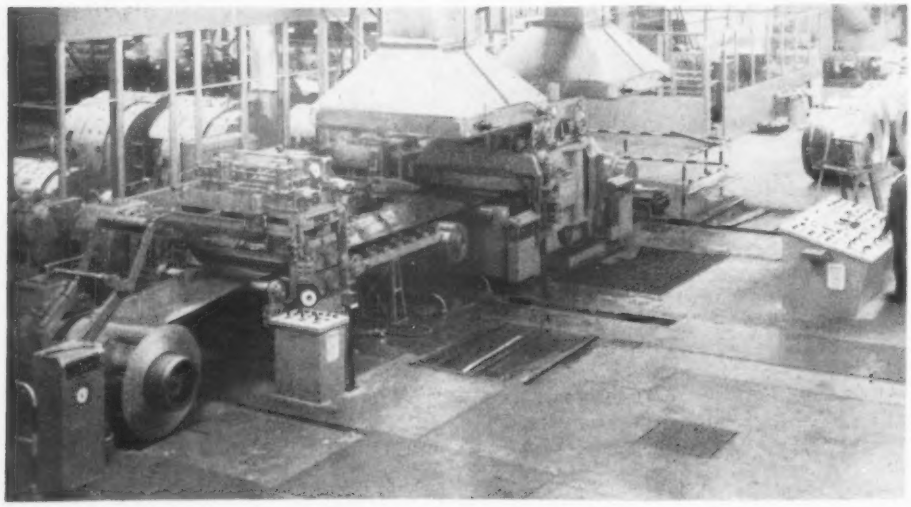

Fig 2—General view of the Sendzimir mill at Birmetals Ltd.

such pressings as door panels and linings, bonnet tops, boot lids and wheel arch pressings as well as a variety of components for commercial vehicles.

For reasons already mentioned, NS6 is less commonly used, and NS7 is used very rarely indeed, except in aircraft applications. Some progress has, however, been made in the wider use of the NS6 material as a result of the introduction of hot pressing techniques.[2]

Curves which illustrate the dependence of strength and ductility on temperature for a few alloys are shown in Fig. 1.

The structure of the alloys of this group is most interesting. Most commercially produced material is given normal annealing treatments with no special rate of cooling, and since, under these conditions, all alloys from 2-7 per cent magnesium have a two-phase structure at room temperature the amount of beta phase present in the finished product will depend on the magnesium content and on the rate of cooling. This phase, present as a precipitate, generally regarded as having the composition Mg_2Al_3 is, however, "soft" and plays no age hardening role, neither does it interfere with deep drawing capacity.

The form of the precipitate is governed also by the previous history of mechanical deformation and the effect of final thermal treatments. In certain rather unusual circumstances the NS6 and NS7 materials can develop a structure which, in an unfavourable environment may render the materials liable to stress corrosion. These circumstances are, however, fairly well established and relate to prolonged exposure at elevated temperatures of cold worked forms of these higher magnesium alloys.

There is no risk attaching to the use of these alloys at room temperature in normal atmospheres nor, indeed, does the hazard apply to the lower magnesium alloys NS4 and NS5 in any conditions of supply or of service so far encountered. Indeed, the popularity of this group of alloys over the past thirty years for shipbuilding and other marine applications, affords testimony to their outstanding durability.

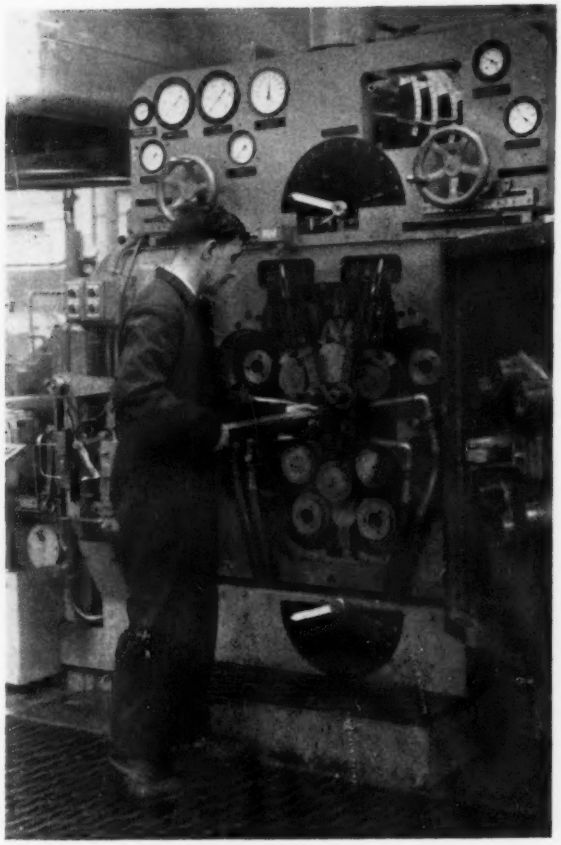

Fig. 3—View of the roll assembly of the Sendzimir mill

It is usual to add a few tenths per cent of manganese or chromium to this type of alloy for the purpose of improving the general corrosion resistance and limiting grain growth. The alloys are normally made with 99·5-99·7 per cent purity base primary aluminium and, in this grade, can be produced in qualities which give pleasing and uniform response to chemical and electrochemical treatments. The same family of alloys is also available on a 99·99 per cent purity base, has similar fabricating characteristics but produces, in the lower magnesium range a higher degree of specular reflectivity in bright anodized material. Naturally, the cost is greater, however, and an intermediate range based on 99·7-99·8 per cent grade aluminium is finding increasing favour for such items of automobile trim as radiator grilles, wheel embellishers, etc.

Aluminium - Magnesium - Silicon Alloys. These are classified under the grades HS20 and HS30. The former is based substantially on a balanced content of magnesium silicide plus a little copper to give added strength, and manganese or chromium as grain growth inhibitors. The latter is low in copper content but has silicon in excess of that required to form the silicide.

TABLE II—TYPICAL MECHANICAL PROPERTIES OF ANNEALED MATERIALS

Material	0·1 per cent Proof Stress tons/in²	Tensile Strength tons/in²	P.S. T.S. per cent	Elongation per cent on 2 in.	V.D.H.	Brinell Hardness	Limiting 180° Bend Radius
99·3 per cent Aluminium	2·0	5·5	36	35	22	21	Flat
Al—1·2 per cent Mn	3·0	7·0	43	35	30	29	Flat
Al—0·6 per cent Mg	3·0	6·8	44	30	27	26	Flat
Al—1 per cent Mg	3·5	8·0	44	30	37	36	Flat
Al—2 per cent Mg	5·0	11·5	43	23	48	45	Flat
Al—3·5 per cent Mg	7·0	15·0	47	25	60	56	Flat
Al—5 per cent Mg	8·2	18·4	45	28	75	72	Flat
Al—7 per cent Mg	10·5	21·5	49	22	105	100	1t
Al—Mg-Si-Cu HS20 Alloy	4·3	9·0	48	20	42	39	Flat
Al—Mg-Si HS30 Alloy	4·7	9·5	49	20	45	42	Flat
Al—Cu-Mg-Si HC15 Alloy	4·5	11·0	41	20	—	—	Flat

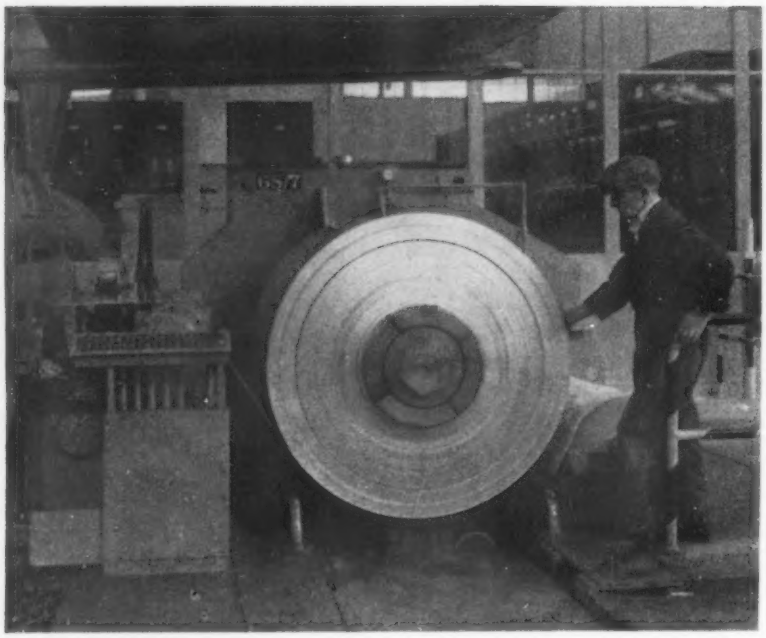

Fig. 4—Coiled strip after rolling in the Sendzimir mill

As a result of their constitution, both materials are responsive to solution and precipitation treatment. Pressing is generally carried out in the soft annealed or in the solution treated condition, the former being normally preferred for the deeper draws. For the less critical operations, material may be pressed shortly after quenching and transferred immediately to the precipitation treatment furnace.

Aluminium-Copper-Magnesium-Silicon Alloys. These are almost exclusively used for aircraft applications where their higher strength is of special interest. The materials are available either "straight" (HS14 and HS15) or clad on both sides with pure aluminium. The clad forms are usually preferred because of their higher intrinsic corrosion resistance. They are then called HC14 and HC15.

Material is usually pressed in the freshly solution-treated condition; a limited delay may be allowed if the treated sheet is held in refrigerated storage to inhibit its strong susceptibility to room temperature age hardening. If required, furnace precipitation treatments may follow after trimming and setting operations. Pressings are less commonly made from annealed sheet in this alloy, partly because subsequent solution treatment could give rise to distortion and render expensive rectification necessary.

Aluminium-Zinc-Magnesium-Copper Alloys. This class of alloy is the strongest of all in the fully heat-treated condition. It is not yet covered by B.S. General Engineering Standards because of its rather restricted use in specialized aircraft. Thus, it appears in the D.T.D. series of specifications published by the Ministry of Aviation. The formability is somewhat limited in the solution-treated condition, although a number of shallow pressings are known to be made in this alloy. In order to avoid the possibility of failure, due to stress corrosion, a phenomenon to which, in certain circumstances, the material can be prone, this sheet alloy is always supplied in the clad condition and its exact usage is very carefully prescribed within the aircraft industry.

The principal aim is to avoid high internal stresses in manufacture and assembly such as could cause concentrations at notches and changes in section. Pressing in the annealed condition is generally expected to be preferred since working stresses will be relieved on solution treatment. Better stress corrosion resistance is developed after precipitation treatment, which is always specified, as is protection by anodizing or painting.

Properties and Characteristics

A comparison of typical properties for most of the alloys in the annealed condition is given in Table II. Some general comments on features related to mechanical properties are given below:

Tensile Strength. This property is rarely measured in isolation, since it has little value even as a check on the general quality of a well-known material. It establishes the stress at which an unworked section of strip will fail under tensile load, but hardly ever do these conditions apply in press-work. Work hardening due to bending and ironing takes place in the metal whilst unidirectional stress is rare, too. At the best, it is a very rough guide. For the same reason, the value of hardness tests shows similar limitations.

Proof Stress. This, the most accurate indication of the onset of yielding in non-ferrous metals, can give most useful information. First, it establishes the stress at which metal will start to flow plastically and is related, though not too exactly, to the stress required to initiate radial drawing of metal from between the die face and the blank-holder.

Proof Stress : Tensile Strength Ratio. Together, the proof stress and the ultimate tensile strength, when expressed as a ratio, are of appreciably more value. The wider this ratio, the greater the plastic range in which deformation can be performed, although even this numerical value does not reveal as much information as does the shape of the load-elongation curve,[3] since the latter will give a measure of the work strengthening effect which occurs over the ductile range of the material.

Ductility. For a material of any given strength, the highest possible ductility is an undoubted asset in the drawing process. The measurement of elongation in the tensile test, a common way of assessing ductility, can, with profit, be divided into two stages; general elongation over a generous gauge length will show the overall tensile ductility of the sheet, whilst measurement over a small distance, spanning the actual fracture, will indicate the capacity for local elongation in the regions of the pressing where necking might be expected to occur, such as over the rim of a small radiused punch used for making a flat bottomed pressing.

Elongation is important, too, in the post-drawing operations. Many pressings, after trimming, are required to have edges folded back or beaded over so as to add rigidity, even though the pressing be a simple one which can be made easily in a quarter-hard or half-hard temper material.

In some deep drawing operations, thinning of the metal due to ironing between the tools, will accompany the general elongation which occurs as a result of tensile stresses in the walls of the component, and this gives rise to consideration of the capacity of a material for deformation in more than one direction. From time to time, suggestions have been made that the reduction in area value is useful in interpreting such behaviour. Its determination on thin sheet is, however, not easy to accomplish with accuracy whilst it only records the limiting case, i.e. the position at fracture. An alternative proposal is to calculate the "R" value

$$\text{Ratio of } \frac{\text{Width Reduction}}{\text{Thickness Reduction}}$$

from measurements which can be accurately made during straining of a specimen. Results which appear to be most interesting in relation to the cup-drawing behaviour of steels have recently been published,[4] and it would be useful to study whether a pattern of results can be related to the practical behaviour of a range of light alloys.

Other tests which have been proposed for assessing multi-directional stressing effects are the wedge-drawing test, hydraulic bulging, and hole widening.[3]

Bend Values. These are normally determined in the laboratory on narrow strips of metal with carefully prepared edges. Whilst such tests serve as an excellent means of sorting out sub-standard material, they have little correlation with the behaviour of wider straight-edge bends and still less with bends on a curve or with the performance of material with indifferent edge preparation. Simple bending is, indeed, rarely met in deep drawing since tensile forces are usually present, too, and one side of the sheet may also be restrained by friction from the freedom of movement it would have in a laboratory test.

An excellent dissertation on fundamental and simulative testing has been given in a most practical way by Murray,[3] and may be strongly recommended, especially to those who, denied the opportunity of press shop experience, still cling hopefully to the development of a cup drawing test to simulate all the features of the complex drawing processes.

Description of the information obtainable from the tensile test has also been given by Arbel,[5] whilst the general subject of control testing is dealt with by Jevons[6,7] both in his standard work and in an excellent review made about a decade ago.

Anisotropy. Since drawing and pressing demand multi - directional movement of the metal the degree of anisotropy present in the sheet obviously demands attention.

It arises from two sources. First, there is the classical case of non-homogeneous deformation,[8] which gives rise to preferred orientations and which is of particular importance in the control of "earing" effects, as will be mentioned later. This can be revealed by X-ray diffraction studies[9] in the most effective manner, but facilities that do not exist to hand are rarely resorted to industrially except as a means of checking the results of simulative drawing tests when establishing new production practices.

Other manifestations of anisotropy are revealed in the "Bauschinger" effect noted in tensile and compression test results from samples in different directions in cold worked sheet of some materials; also, the general tendency shown in tensile properties for the ductility to be lower transverse to the rolling direction and, moreover, sharply affected by the presence of rolled out stringers of harder second phase constituents in the alloy.

Grain Size. This feature is universally regarded as of importance in material for presswork. Generally speaking, when annealed materials are employed, complete re-crystallization should be assured and, since the ductility increases as the grain size gets larger, some degree of grain growth is permissible, subject only to preventing the appearance of "orange peel" surface which increases the difficulty of subsequent polishing operations.

Naturally, every alloy has its own characteristic grain size features which are governed not only by the composition but by the thermal and mechanical history during the later stages of production.

Special circumstances arise in the aluminium - magnesium alloys which demand a somewhat larger grain size, and these will be discussed later.

The use of material of too coarse a grain size will render the pressing likely to fail prematurely in areas of high local deformation as at sharp punch or die radii and in the upper part of the walls of drawn cylindrical components.

Metal Thickness. It is becoming increasingly recognized that close tolerance on gauge is essential to trouble-free pressing. Two facts should, however, be borne continuously in mind. First, it is pointless for the customer to demand closer gauge tolerances than his presses can accommodate. In this connection, it is still not unusual to find operators of single-acting mechanical friction presses which are in a poor condition as regards slide clearance, thinking that tighter gauge control is the answer to their frequent failures. Secondly, metal rolled to specially close tolerances will normally be at a premium in price. The more extensive introduction of wide strip rolling which has been seen in the aluminium industry in the last few years, and particularly the commissioning of equipment such as the 50 in. wide Sendzimir strip mill shown in Figs. 2-4, is gradually making the availability of high quality products more general at an economic cost.

Surface Finish. With ferrous metals, care is taken to utilize clean, rust-free sheet stock as far as possible. There is, however, a school of thought which gives preference to what is termed a "mill finish" sheet, i.e. a very slightly matte texture, arising from the roll surface, rather than a bright finish sheet. To a small extent, this opinion also prevails with regard to light alloys. Some press operators are heard to say that it holds the lubricant better. Claims have also been made for improved deep drawability of phosphate-treated steel sheet, although the same sort of claims have never, in the author's opinion, been substantiated for light alloy sheet treated by conversion coating processes, such as the chromate - oxidation or phosphating treatments, which are normally used for paint keying.

There is a certain amount of evidence to suggest that in simple cup drawing of any metal it is advantageous to have a higher coefficient of surface friction on the side of the blank nearest the punch. This has not been commercially exploited in respect of light alloy pressings, and the general practice is to use tools polished as highly as practicable.

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(To be continued)

Heat Transfer Between Metals

BASIC information has been obtained by the National Engineering Laboratory on some of the factors which affect the transfer of heat between two machined metal surfaces. The transfer of heat between solid surfaces is widespread, for example, between fuel rods and cans which are in static contact in a nuclear reactor, and between the riveted components of an aircraft subjected to aerodynamic heating.

Measurements of the heat transfer between machined metal contacts have been made with brass and aluminium surfaces of four different values of roughness in contact with steel and brass surfaces of two different roughnesses. Contact pressure was varied between 14 and 11,400 lb/in^2.

It was found that most of the heat was transferred by surface contact and conduction through the intervening fluid. The fluid conductance was found, as expected, to be directly proportional to the thermal conductivity of the fluid and inversely proportional to an "effective fluid film thickness"; the way in which the effective fluid film thickness depended on surface roughness was determined.

The conductance through surface contact was dependent on applied pressure, surface hardness, surface finish, and the thermal conductivities of the solids; the relation between these factors was obtained. A theoretical expression for the surface contact conductance has been developed, based on the resistance to heat flow associated with a constriction. It gave good agreement with the experimental results when the variation of metal hardness with load in the micro-hardness region was taken into account.

This work was carried out for N.E.L. at the Imperial College of Science and Technology, University of London.

ELECTRODEPOSITION OF RUTHENIUM — PLAIN BEARING MANUFACTURE

I.M.F. Annual Conference

AT the Second Technical Session of the Institute of Metal Finishing at Llandudno, three Papers came up for discussion. The first two of these, dealing respectively with the electrodeposition of ruthenium and electrodeposition in plain bearing manufacture, are abstracted on this and the following page. A report of the discussions and the authors' replies are also published.

The discussion on the Paper by F. H. Reid and J. C. Blake was opened by R. R. Benham.

DISCUSSION

R. R. Benham (Johnson, Matthey and Co. Ltd.) said he would confine his attention in the main to the nitrosyl-sulphamate electrolyte, as this appeared the most promising.

Cathode efficiency was stated to be 21 per cent at a temperature of 90° C. and there was, presumably, considerable evolution of hydrogen. Did this give rise to hydrogen pits in the deposit, such as sometimes occurred with rhodium plating? The problem of loss of the volatile tetroxide from the anode seemed a distinct disadvantage, and must be overcome before the bath could be exploited commercially. In the Paper, 2·5 gm/L. of ruthenium was stated to be the essential minimum, below which the tetroxide was not involved. Was that the complete position, or was there some small evolution below that concentration?

It was stated that good deposits of up to 0·0002 in. were obtainable. While this might be all right for many applications, it was on the thin side for heavy duty work. Could some information be given on the quality of thicker deposits? Why had the upper limit been set at 0·0002 in? It was said that ruthenium, like rhodium, was subject to spontaneous cracking at about 0·0001 in. unless additions of aluminium or magnesium sulphate were made to the electrolyte. Selenium had, in the past, been used for this purpose in rhodium baths. Had it been tried in ruthenium solutions?

Reid and others had shown that the incidence of cracking was influenced by the undercoat, e.g. in the case of rhodium it was considerably less on an undercoat of silver than on one of nickel. From the slide shown it would appear true also for ruthenium. The drop in cathode efficiency with ruthenium was certainly unexpected, and the only other similar reference he could recall was by Parker in an article in connection with barrel gold plating. He had attributed it to the normal decrease in throwing power with increasing concentration of gold.

In the plating tests which the authors had carried out on copper and brass they had found it necessary to give a preliminary flash with gold or a similar substance in order to prevent attacks by the electrolyte. Had they considered striking the ruthenium solution at a higher current density to achieve direct deposition on base metals?

He would like clarified a point on p. 50 where, in giving information about occlusion of non-metallic material in deposition from a solution containing aluminium, the authors said that spectrographic examination, except in the case of the latter substance, had been inconclusive. He would have thought that if aluminium were present in some form it would be detected quite easily spectrographically.

The nitrosyl-free electrolyte appeared more promising than the sulphamate solution, apart from the loss of tetroxide. The authors stated that the use of a diaphragm cell might be the answer to the problem. Had they any further information on the point of application of ruthenium? If it could be confirmed that deposits would withstand higher intensity arcing without pitting, as stated on p. 46, it would be a valuable property which might find application in sparking plugs.

It seemed that rhodium would continue to hold its place in high frequency contact applications because of the lower resistivity of 4·3 microhms/cm., compared with 7·6 for ruthenium. Ruthenium was, of course, rather dark in colour. One saw in Table I that ruthenium had a reflectivity of 63 per cent, compared with 79 per cent for rhodium. Ruthenium, therefore, might not be acceptable for domestic use. The darkening effect was more noticeable, of course, on articles with internal reflections where the loss of reflected light was more apparent. Colour was, of course, a matter of opinion and fashion, and subject to change. Ruthenium was not well known by the lay public and doubtless an intensive sales drive would be necessary before it would be accepted. Rhodium had been used for about 30 years but was still not appreciated generally as being of high intrinsic value. He was still asked sometimes whether rhodium plating was a substitute for chromium.

On behalf of Hopkins, he then put the following additional questions to the authors: what is the effect on the deposit, and on the life of the bath, of using a divided cell? What is the effect of less acid being present? What compounds build up in the solution after a ruthenium turnover of 250 per cent? Does the cathode efficiency of the bath alter with use? Are there any signs that the solution ages with use or on standing? What are the effects of the use of addition agents such as sodium phosphate or sulphate, or the salts of a sulphamic acid?

J. M. Sprague (Consulting Electrochemist) said the authors had deliberately presented their results in terms of a formula for their starting material which was not really correct. The more complex formula might throw more light on the results. Were the two ruthenium atoms acting with different valencies? If so, could this have any bearing on the current efficiency? Could one start with a ruthenium compound in which the ruthenium content operated with a single known valency? It might be useful to try to ascertain what ions were concerned, giving a guide to what one was operating with, or might try to operate with. The authors had given a tentative explanation for the rather surprising decline in efficiency with increased metal content. Was it possible that as one increased the metal content one increased the complexing ion that was there? After all, one did this with a cyanide solution.

In the early work on tungsten, a metal with a very complex chemistry, it had been found impossible to obtain pure tungsten deposits, but relatively easy to obtain tungsten with iron and certain other transitional elements. However one calculated it, the ruthenium bath in question had a very low efficiency.

Referring to undercoating, he said that when a metal was stripped from its substrate it simply meant that the stress in the deposit was greater than the forces of adhesion, and it was possible to decrease the one or increase the other. The soft metals gave better adhesion. Could not something less expensive than gold be tried, yet a soft metal in which the stress in the deposit might ease itself to some

Electrodeposition of Ruthenium

By F. H. REID and J. C. BLAKE

EXPLORATORY plating tests have been carried out on a number of aqueous electrolytes based on simple ruthenium salts and nitrosyl derivatives. The nitrosyl sulphamate electrolyte emerges as the most immediately useful solution, furnishing smooth, bright deposits of ruthenium up to 0·0002 in. thick over a fairly wide range of operating conditions. Cathode efficiency is always low and under preferred operating conditions is in the range of 10%-20%. Deposits show internal tensile stresses of the order of 20-30 tons/in² and fine cracks may be present at thicknesses greater than 0·0001 in. Cracking is reduced by addition of aluminium sulphate to the electrolyte. The simple sulphamate solution and an electrolyte based on reaction of sodium tetranitro-nitrosyl-ruthenate with sulphamic acid give slightly better performance than the nitrosyl-sulphamate solution when freshly prepared, but are considerably less stable in operation.

As expected, electrodeposited ruthenium resembled rhodium in its general characteristics. In the applicational field, the place for ruthenium vis-a-vis palladium and rhodium remains to be established but, whatever specialized uses may develop, the electrodeposited metal offers a possible economic alternative to rhodium in electrical contact applications, and in this context preliminary assessments of corrosion resistance, wear rate and resistive noise levels for ruthenium coatings 0·0001 in. thick on brass have indicated that their performance does not fall far short of that of rhodium finishes of similar thickness.

(*Trans. Inst. Met. Fin.*, 1961, **38**, (2), 45)

extent. Was it possible, without embarking upon complications, to consider the use of stress relievers?

Dr. T. P. Hoar (University of Cambridge) asked why the cathode efficiency for the deposition of a noble metal was so extremely low? From Fig. 2 it seemed that the cathode efficiency went up sharply with temperature. Ruthenium was a noble metal, and the reason must be that the over-voltage was astonishingly high. This fitted in with the increased cathode efficiency with increased temperature in suggesting that the over-voltage was much higher than that for hydrogen, and had a high temperature coefficient as it were.

Some years earlier he had reported some work on tungsten cobalt. Here again he had found a low cathode efficiency—never greater than about 20 or 25 per cent, but the interesting thing there, in comparison with ruthenium, was that the over-voltage of deposition of pure tungsten from a solution not containing iron cobalt was so high that one could not get it down at all.

AUTHOR'S REPLY

F. H. Reid, replying, said that ruthenium, rhodium and other precious metals were bound to be bracketed together in discussion, because they were superficially similar at least. They had been glad to include the results of unsuccessful experiments because sometimes the successes only tended to be emphasized, and the failures passed over. They hoped to give anyone else who took up the work a sufficient basis on which to proceed. They had not found, with ruthenium plating, hydrogen pitting due to low efficiency, such as occurred to some extent with rhodium. Deposits were normally fairly smooth: there might be a little pitting here and there, but it was not troublesome.

They had limited the thickness of deposit to 0·0002 in. for the sake of convenience. This was quite sufficient for almost all of the applications one could foresee for ruthenium. One seldom needed more than this with rhodium, even for heavy duty applications, because it was as hard as ruthenium and normally used as a contact with a softer material.

They had made the point that the effect upon cracking of the undercoat was marginal. If one had a slightly stressed deposit it would crack badly on almost any undercoat. When they had spoken of cracking they had been referring to a kind of borderline between two extremes where the effects were rather magnified. He would agree that silver or gold would tend to relieve the stress because it was soft, but this was a factor about which one should not be too forceful. On the question of the "mysterious" decrease in cathode efficiency with increased ruthenium content, he had a feeling that it was probably deposited through a cathode film: that in increasing the ruthenium concentration they were thickening the film.

They had tried a high current density strike to overcome the effect of poor adhesion, and the results had not been promising. There was a similar situation with rhodium and the nitrosyl groups. It seemed a feature of this type of bath that the deposit went on perfectly well but after two days or so it began to fall off.

The spectrographic results had been inconclusive because their standards were not sufficiently high—indeed, none were available. They had not intended to imply that there was no significant degree of aluminium in the deposit. The use of diaphragm cells had been referred to. He could only say at this stage that the results had not been very promising. To take a simple sulphamate bath as an example, with the diaphragm cell they tended to get rather blackish deposits on the cathode.

Acid concentration did not seem to have a very big effect — indeed no measurable effect — on the deposits in appearance. As to what compounds built up on the solution after use, the chemistry of the ruthenium compound used was very abstruse. The formulae quoted in the Paper were obtained as a result of work carried out at the Battersea College of Advanced Technology, and the chemistry had been very involved. Sprague and Dr. Hoar had referred to the theoretical aspects. He agreed that they should look into the bath measurements on the lines suggested. This was, however, a piece of applicational research. Results would always be very hard to interpret because of the complications inherent. If one made up the solution in any of three or four different ways one got that many answers. Despite this, a bath which was useful for depositing ruthenium in workable thicknesses could be prepared.

It was difficult to see where ruthenium would be used. He felt it would find its own applications. Benham had said that rhodium would be better in high frequency circuits, but the conductivity of the electrical deposit was not necessarily the same. One should not apply the values for wrought metals to electrodeposits. There were signs that the addition of palladium to the bath might give increased cathode efficiency.

On the question why there was a low cathode efficiency with a noble metal, the only reference he could give was a Paper by Lyons, in which he had referred to the so-called "inner orbital" patches which these metals formed so easily. They were very strongly complexed. The metals could be deposited from aqueous solutions as the stability of the metallic state was very high.

Electrodeposition in Plain Bearing Manufacture

By P. G. FORRESTER

ELECTRODEPOSITION has been used for providing bearing linings of numerous different materials. Silver and silver-lead are the only electrodeposited materials which have been used on a large scale to provide complete linings. Plating is, however, the standard method for providing the thin lead-base overlay on copper-lead bearings, which are among the principal high duty bearings in current use. Much attention has been given to means of applying thin overlays reliably and accurately. In bearing manufacture, accuracies of 0·00025 in. to 0·0005 in. are demanded, and carefully controlled plating after machining is necessary. Two very different methods are in use. The first uses an anode placed centrally in a cylinder formed by two stacks of half-bearings. In lead-tin fluoborate solutions, where current distribution is determined largely by geometry, this method is capable of great accuracy.

The alternative method is that of plating through a slot. This method uses a non-conducting rectangular box, one wall of which has a central slot along its length, and the bearings are placed with the bores facing this slot. The slot can be regarded as behaving in some ways like an anode. The simple slot tends to favour plating away from the centres or crown of the bearing, a tendency which can be reduced by means of baffles placed along the slot.

Two developments of the slot method have been described. One uses a series of holes in place of a continuous slot; the second uses a square-sectioned box, with slots on all four sides. Both slot and cylinder methods can give good results; both have their limitations and advantages.

Certain aluminium alloys provide a suitable combination of hardness and strength and by the addition of metals such as tin, which form alloys with soft phases, good bearing surface properties can be obtained, and aluminium-tin on steel bearings are now in very large-scale production. Aluminium alloys have also been used to a limited extent as an interlayer for overlay bearings in place of copper-lead.

The performance of overlays is limited by liability to fatigue, cavitation and wear, examples of which are given in the Paper. Electrodeposition is also widely used as a corrosion protection for bearings and to assist in obtaining a bond in various types of bimetal.

(*Trans. Inst. Met. Fin.*, 1961, **38,** (2), 29)

DISCUSSION

In the discussion on the Paper dealing with electrodeposition of plain bearings, Dr. D. N. Layton made the first contribution.

Dr. D. N. Layton (Ionic Plating Co. Ltd.) said a number of the alloys with which the author would no doubt dearly love to deal, e.g., antimony, had high hydrogen over-voltages. This led to complications in depositing the metal on its own. He felt that the problem of depositing alloys on some of these metals would only be solved if, instead of the empirical approach used so far, there were a more fundamental one involving the investigation of the basic electrochemistry of the processes.

Also of interest was the method used by bearing manufacturers to obtain uniform deposition in half shells, and the use of slots in a plastics shield as the anode. This gave an effective line anode down a jig made up by stamping a number of semi-circular shells on top of each other. He was particularly pleased with the present example because so often electrodepositors faced with a bad deposit distribution resorted to the use of burners to take the current off the high density area and produce a high density deposit over the area in which they were especially interested. This was only making a bad current density distribution even worse.

The only quantitative data on the subject were in the patent literature and one or two of the Papers by Mohler. He would add that one of Schaefer's American patents contained some quantitative data which were not consistent. The deposit

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He would like clarified a point on p. 50 where, in giving information about occlusion of non-metallic material in deposition from a solution containing aluminium, the authors said that spectrographic examination, except in the case of the latter substance, had been inconclusive. He would have thought that if aluminium were present in some form it would be detected quite easily spectrographically.

The nitrosyl-free electrolyte appeared more promising than the sulphamate solution, apart from the loss of tetroxide. The authors stated that the use of a diaphragm cell might be the answer to the problem. Had they any further information on the point of application of ruthenium? If it could be confirmed that deposits would withstand higher intensity arcing without pitting, as stated on p. 46, it would be a valuable property which might find application in sparking plugs.

It seemed that rhodium would continue to hold its place in high frequency contact applications because of the lower resistivity of 4·3 microhms/cm., compared with 7·6 for ruthenium. Ruthenium was, of course, rather dark in colour. One saw in Table I that ruthenium had a reflectivity of 63 per cent, compared with 79 per cent for rhodium. Ruthenium, therefore, might not be acceptable for domestic use. The darkening effect was more noticeable, of course, on articles with internal reflections where the loss of reflected light was more apparent. Colour was, of course, a matter of opinion and fashion, and subject to change. Ruthenium was not well known by the lay public and doubtless an intensive sales drive would be necessary before it would be accepted. Rhodium had been used for about 30 years but was still not appreciated generally as being of high intrinsic value. He was still asked sometimes whether rhodium plating was a substitute for chromium.

On behalf of Hopkins, he then put the following additional questions to the authors: what is the effect on the deposit, and on the life of the bath, of using a divided cell? What is the effect of less acid being present? What compounds build up in the solution after a ruthenium turnover of 250 per cent? Does the cathode efficiency of the bath alter with use? Are there any signs that the solution ages with use or on standing? What are the effects of the use of addition agents such as sodium phosphate or sulphate, or the salts of a sulphamic acid?

J. M. Sprague (Consulting Electrochemist) said the authors had deliberately presented their results in terms of a formula for their starting material which was not really correct. The more complex formula might throw more light on the results. Were the two ruthenium atoms acting with different valencies? If so, could this have any bearing on the current efficiency? Could one start with a ruthenium compound in which the ruthenium content operated with a single known valency? It might be useful to try to ascertain what ions were concerned, giving a guide to what one was operating with, or might try to operate with. The authors had given a tentative explanation for the rather surprising decline in efficiency with increased metal content. Was it possible that as one increased the metal content one increased the complexing ion that was there? After all, one did this with a cyanide solution.

In the early work on tungsten, a metal with a very complex chemistry, it had been found impossible to obtain pure tungsten deposits, but relatively easy to obtain tungsten with iron and certain other transitional elements. However one calculated it, the ruthenium bath in question had a very low efficiency.

Referring to undercoating, he said that when a metal was stripped from its substrate it simply meant that the stress in the deposit was greater than the forces of adhesion, and it was possible to decrease the one or increase the other. The soft metals gave better adhesion. Could not something less expensive than gold be tried, yet a soft metal in which the stress in the deposit might ease itself to some

Electrodeposition of Ruthenium

By F. H. REID and J. C. BLAKE

EXPLORATORY plating tests have been carried out on a number of aqueous electrolytes based on simple ruthenium salts and nitrosyl derivatives. The nitrosyl sulphamate electrolyte emerges as the most immediately useful solution, furnishing smooth, bright deposits of ruthenium up to 0·0002 in. thick over a fairly wide range of operating conditions. Cathode efficiency is always low and under preferred operating conditions is in the range of 10%-20%. Deposits show internal tensile stresses of the order of 20-30 tons/in² and fine cracks may be present at thicknesses greater than 0·0001 in. Cracking is reduced by addition of aluminium sulphate to the electrolyte. The simple sulphamate solution and an electrolyte based on reaction of sodium tetranitro-nitrosyl-ruthenate with sulphamic acid give slightly better performance than the nitrosyl-sulphamate solution when freshly prepared, but are considerably less stable in operation.

As expected, electrodeposited ruthenium resembled rhodium in its general characteristics. In the applicational field, the place for ruthenium vis-a-vis palladium and rhodium remains to be established but, whatever specialized uses may develop, the electrodeposited metal offers a possible economic alternative to rhodium in electrical contact applications, and in this context preliminary assessments of corrosion resistance, wear rate and resistive noise levels for ruthenium coatings 0·0001 in. thick on brass have indicated that their performance does not fall far short of that of rhodium finishes of similar thickness.

(*Trans. Inst. Met. Fin.*, 1961, **38**, (2), 45)

extent. Was it possible, without embarking upon complications, to consider the use of stress relievers?

Dr. T. P. Hoar (University of Cambridge) asked why the cathode efficiency for the deposition of a noble metal was so extremely low? From Fig. 2 it seemed that the cathode efficiency went up sharply with temperature. Ruthenium was a noble metal, and the reason must be that the over-voltage was astonishingly high. This fitted in with the increased cathode efficiency with increased temperature in suggesting that the over-voltage was much higher than that for hydrogen, and had a high temperature coefficient as it were.

Some years earlier he had reported some work on tungsten cobalt. Here again he had found a low cathode efficiency—never greater than about 20 or 25 per cent, but the interesting thing there, in comparison with ruthenium, was that the over-voltage of deposition of pure tungsten from a solution not containing iron cobalt was so high that one could not get it down at all.

AUTHOR'S REPLY

F. H. Reid, replying, said that ruthenium, rhodium and other precious metals were bound to be bracketed together in discussion, because they were superficially similar at least. They had been glad to include the results of unsuccessful experiments because sometimes the successes only tended to be emphasized, and the failures passed over. They hoped to give anyone else who took up the work a sufficient basis on which to proceed. They had not found, with ruthenium plating, hydrogen pitting due to low efficiency, such as occurred to some extent with rhodium. Deposits were normally fairly smooth: there might be a little pitting here and there, but it was not troublesome.

They had limited the thickness of deposit to 0·0002 in. for the sake of convenience. This was quite sufficient for almost all of the applications one could foresee for ruthenium. One seldom needed more than this with rhodium, even for heavy duty applications, because it was as hard as ruthenium and normally used as a contact with a softer material.

They had made the point that the effect upon cracking of the undercoat was marginal. If one had a slightly stressed deposit it would crack badly on almost any undercoat. When they had spoken of cracking they had been referring to a kind of borderline between two extremes where the effects were rather magnified. He would agree that silver or gold would tend to relieve the stress because it was soft, but this was a factor about which one should not be too forceful. On the question of the "mysterious" decrease in cathode efficiency with increased ruthenium content, he had a feeling that it was probably deposited through a cathode film: that in increasing the ruthenium concentration they were thickening the film.

They had tried a high current density strike to overcome the effect of poor adhesion, and the results had not been promising. There was a similar situation with rhodium and the nitrosyl groups. It seemed a feature of this type of bath that the deposit went on perfectly well but after two days or so it began to fall off.

The spectrographic results had been inconclusive because their standards were not sufficiently high—indeed, none were available. They had not intended to imply that there was no significant degree of aluminium in the deposit. The use of diaphragm cells had been referred to. He could only say at this stage that the results had not been very promising. To take a simple sulphamate bath as an example, with the diaphragm cell they tended to get rather blackish deposits on the cathode.

Acid concentration did not seem to have a very big effect — indeed no measurable effect — on the deposits in appearance. As to what compounds built up on the solution after use, the chemistry of the ruthenium compound used was very abstruse. The formulae quoted in the Paper were obtained as a result of work carried out at the Battersea College of Advanced Technology, and the chemistry had been very involved. Sprague and Dr. Hoar had referred to the theoretical aspects. He agreed that they should look into the bath measurements on the lines suggested. This was, however, a piece of applicational research. Results would always be very hard to interpret because of the complications inherent. If one made up the solution in any of three or four different ways one got that many answers. Despite this, a bath which was useful for depositing ruthenium in workable thicknesses could be prepared.

It was difficult to see where ruthenium would be used. He felt it would find its own applications. Benham had said that rhodium would be better in high frequency circuits, but the conductivity of the electrical deposit was not necessarily the same. One should not apply the values for wrought metals to electrodeposits. There were signs that the addition of palladium to the bath might give increased cathode efficiency.

On the question why there was a low cathode efficiency with a noble metal, the only reference he could give was a Paper by Lyons, in which he had referred to the so-called "inner orbital" patches which these metals formed so easily. They were very strongly complexed. The metals could be deposited from aqueous solutions as the stability of the metallic state was very high.

Electrodeposition in Plain Bearing Manufacture

By P. G. FORRESTER

ELECTRODEPOSITION has been used for providing bearing linings of numerous different materials. Silver and silver-lead are the only electrodeposited materials which have been used on a large scale to provide complete linings. Plating is, however, the standard method for providing the thin lead-base overlay on copper-lead bearings, which are among the principal high duty bearings in current use. Much attention has been given to means of applying thin overlays reliably and accurately. In bearing manufacture, accuracies of 0·00025 in. to 0·0005 in. are demanded, and carefully controlled plating after machining is necessary. Two very different methods are in use. The first uses an anode placed centrally in a cylinder formed by two stacks of half-bearings. In lead-tin fluoborate solutions, where current distribution is determined largely by geometry, this method is capable of great accuracy.

The alternative method is that of plating through a slot. This method uses a non-conducting rectangular box, one wall of which has a central slot along its length, and the bearings are placed with the bores facing this slot. The slot can be regarded as behaving in some ways like an anode. The simple slot tends to favour plating away from the centres or crown of the bearing, a tendency which can be reduced by means of baffles placed along the slot.

Two developments of the slot method have been described. One uses a series of holes in place of a continuous slot; the second uses a square-sectioned box, with slots on all four sides. Both slot and cylinder methods can give good results; both have their limitations and advantages.

Certain aluminium alloys provide a suitable combination of hardness and strength and by the addition of metals such as tin, which form alloys with soft phases, good bearing surface properties can be obtained, and aluminium-tin on steel bearings are now in very large-scale production. Aluminium alloys have also been used to a limited extent as an interlayer for overlay bearings in place of copper-lead.

The performance of overlays is limited by liability to fatigue, cavitation and wear, examples of which are given in the Paper. Electrodeposition is also widely used as a corrosion protection for bearings and to assist in obtaining a bond in various types of bimetal.

(*Trans. Inst. Met. Fin.*, 1961, **38,** (2), 29)

DISCUSSION

In the discussion on the Paper dealing with electrodeposition of plain bearings, Dr. D. N. Layton made the first contribution.

Dr. D. N. Layton (Ionic Plating Co. Ltd.) said a number of the alloys with which the author would no doubt dearly love to deal, e.g., antimony, had high hydrogen over-voltages. This led to complications in depositing the metal on its own. He felt that the problem of depositing alloys on some of these metals would only be solved if, instead of the empirical approach used so far, there were a more fundamental one involving the investigation of the basic electrochemistry of the processes.

Also of interest was the method used by bearing manufacturers to obtain uniform deposition in half shells, and the use of slots in a plastics shield as the anode. This gave an effective line anode down a jig made up by stamping a number of semi-circular shells on top of each other. He was particularly pleased with the present example because so often electrodepositors faced with a bad deposit distribution resorted to the use of burners to take the current off the high density area and produce a high density deposit over the area in which they were especially interested. This was only making a bad current density distribution even worse.

The only quantitative data on the subject were in the patent literature and one or two of the Papers by Mohler. He would add that one of Schaefer's American patents contained some quantitative data which were not consistent. The deposit

distribution and thicknesses were not consistent with the claimed plating conditions. He had not heard it queried before. If one made the slot narrower, eventually one got completely uniform deposition around the half circle. The slot width had to be about 11 per cent or less of the half shell diameter. If the little ears were put on the slot, as shown in Fig. 4C, the slot could be opened up to between 25 and 38 per cent of the shell diameter. This must, of course, reduce the losses in deposition. The ears made a wider slot possible.

J. M. Sprague (Consulting Electrochemist) said that the problem of particles of the lubricant not getting out was of long standing so far as electrodepositors were concerned. How far was this a question of rate of turnover per lubricant? Could the author give a little more practical detail concerning how much could be achieved in this way. Several of the bars to which he had referred did not make use of alloy anodes although alloy deposits were obtained. Would it not be more manageable to use alloy anodes in such cases?

R. A. F. Hammond (Armament Branch and Dev. Establishment, War Office) said that the author had made it clear that one of the mechanisms of failure in bearings was that of fatigue. Was it a question of straight fatigue or corrosion fatigue? If it was straight fatigue, was there any possibility of reducing the risk of this by incorporating some addition agent in the bath—one that would give compressive instead of tensile stress in the deposit? He realized that with such soft coatings it was unlikely that one could get very much stress of either kind. If it was a question of corrosion fatigue, was anything being done to overcome it by the use of inhibitors in the lubricant?

C. Williams said that from Figs. 5 and 6 it seemed that the fatigue in the top coating had not spread to the underlying coating. Were these examples of non-propagation of fatigue cracks and, therefore, of little consequence? In Fig. 7 the fatigue crack apparently did not go through to the underlay. Was it a case of the fatigue crack resulting in the detachment of the coating rather than propagating to the basic material to cause failure of the part?

AUTHOR'S REPLY

P. G. Forrester, in reply, apologized for not having expressed himself with sufficient clarity on the question of fatigue. The phenomena of bearing fatigue was fairly well known but not at all well understood. If a bearing was overloaded, and too high an alternating compressive stress applied, it cracked. There was much literature on the subject but little progress has been made towards elucidation in the last twenty years. The limit figure for a given material was fairly consistent, and if it were exceeded, cracks having all the appearance of being due to fatigue appeared. They occurred after a specific number of reversals and followed the usual pattern. As indicated in Fig. 7, they began at the surface and ran down until they were fairly close to the bond with a stronger material, then along this and back to the surface or, alternatively, joined another crack in so doing. Ultimately there was complete separation of pieces. In view of the high oil pressures — 3,000 or 4,000 lb/in^2 — penetration of cracks could occur, with consequent damage to the lining. If it was just an overlay lining the effects were not catastrophic because it would only wear, but if a whole lining was involved, this simply disappeared.

He had not previously heard it suggested that one might deliberately insert compressive stress. It was interesting, but it might be difficult to maintain a compressive stress in a soft material, though not impossible. Perhaps some of the unresolved difficulties might be due to differences of that kind. He added that the method of testing adopted had been to build a bearing testing machine which applied these alternating stresses, operate it for a given number of reversals and observe the extent of failure in the bearing. Testing time varied a good deal.

He did not think that corrosion fatigue was involved. They had looked for this but had not been able to observe any difference in effect as between different lubricants. Some were, of course, inhibited. It did not seem to have any effect in the alloys named but did appear on a large scale in copper-lead alloys. The lead phase was attacked and this weakened the whole structure.

The aim should not be to get compositions identical to those which proved successful in the cast form, but rather to obtain the properties desired. If a material based on tin or lead with a hardness of about 25, and running down to about 10, at 160°C. was required, it might be easier to begin in that way.

I.B.F. Conference

The accompanying photographs show some of the personalities at the Annual Conference of the Institute of British Foundrymen at Cheltenham.

Right: Mr. and Mrs. G. R. Shotton (Retiring President), Mr. and Mrs. D. A. Richards (President)

Below Left: Mr. and Mrs. G. R. Webster (Senior Vice President), Mr. and Mrs. W. R. Buxton

Below Right: Mr. and Mrs. E. A. Peace (Past President), Mr. and Mrs. R. F. Horton (Junior Vice-President), Mr. and Mrs. E. Longden (Past President)

New Plant & Equipment

Plate Shearing

SPECIALLY designed for inclusion at the end of a "cut-to-length" automatic line, a modern up-cutting shears incorporating their patented "fluid drive" principle has been supplied by Joseph Rhodes and Sons Ltd., Wakefield, to the Stocksbridge works of Samuel Fox and Co. Ltd. The equipment is capable of shearing up to a maximum thickness of 1 in. of mild steel or $\frac{3}{4}$ in. of stainless steel, to a maximum width of 6 ft. 6 in. The cutting rate of the shears on plate up to $\frac{3}{8}$ in. thick is 20 strokes/min., and on thicker plate 6 strokes/min.

In the "fluid drive" method of actuation, an electro-hydraulic source of power is used to actuate the mechanical action of the shears. The hydraulic power provides an easily regulated and controlled motive force, whilst the mechanical action ensures high speeds with precision of movement. There are no clutches, rotating shafts, gears, flywheels; the fluid drive limits the load which can be put upon the machine, and eliminates any ill effects due to accidental overload. The relief valve in the hydraulic circuit ensures full safety against overload, as should any overload occur the beam would immediately return to its top of stroke position.

Being of the up-cutting type, the shears allows the line conveyor to be maintained at a fixed height, a great advantage over the orthodox down-cutting shears which would necessitate an automatic dipping conveyor on the outgoing side of the line.

Heating Small Billets

SPECIALLY designed by the South Western Gas Board for the heating of brass and aluminium billets for hot pressing and forging, a furnace introduced by Industrial Furnaces Ltd., of Kingswinford, Staffs., offers constant throughput of billets, even heating and improved working conditions.

Robustly constructed, it is fired by town's gas, with natural draught gas burners, thermostatic control, and automatic ignition. Operation may be electric or pneumatic, as required.

Four models are available, for billets from 1 in. dia $\times \frac{1}{2}$ in. long to 4 in. dia. $\times 1\frac{1}{2}$ in. long.

The billet is fed into the top of the furnace from a vibratory or other type feeder. It is then rotated at eight levels through the furnace. Gradual heating takes place at each level until the billet is ejected from the furnace at the required temperature.

The discharge rate of the billets is dependent on the feed control arrangement and may be cycled in time or manually controlled.

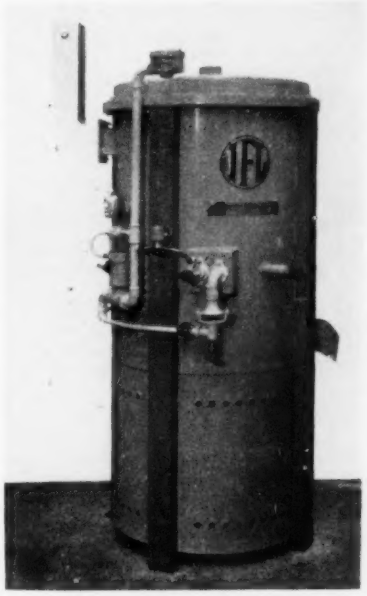
Automatic temperature control ensures constant thermal conditions. The maximum working temperature is 900°C.

The driving gear which propels the billets through the furnace is fitted in the enclosed section under the furnace.

Stud Welding

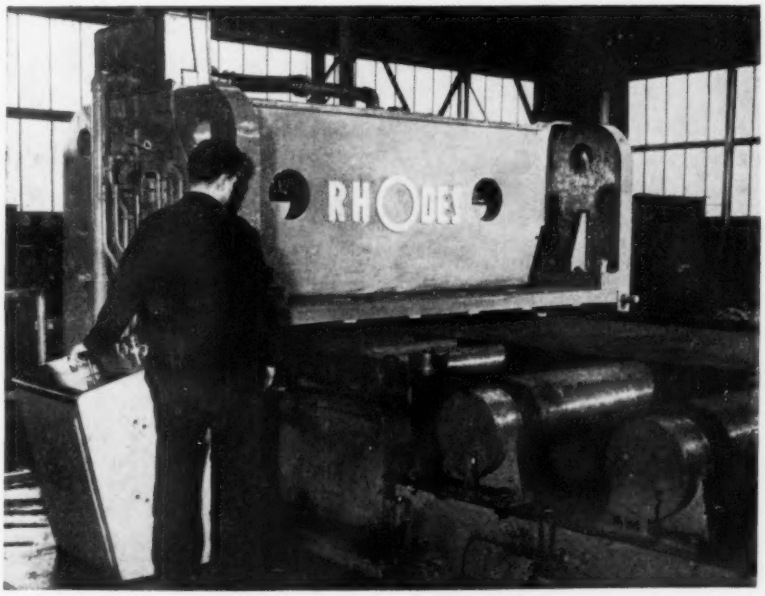
CAPACITOR discharge stud welding equipment which can be connected direct to single-phase 13 amp. power sources is being introduced to this country by K.S.M. Stud Welding Ltd., Old Woking, Surrey. The main components of the new equipment consist of: a large bank of capacitors, 100,000 MFD being about the minimum for practical purposes; a power pack of sufficient size to charge these capacitors, after their complete discharge, some 10 or 12 times a minute; a variable transformer enabling accurate charging of the capacitors to any predetermined amount. In practice, they are charged to a specified voltage, which is indicated on a meter, this voltage being selected by reference to charts, or after a while, from experience. A switch is also included for making contact to the capacity bank and automatically charging these capacitors after their discharge. In practice, this is, in fact, a specially designed contactor. Associated circuitry ensures repetitive accuracy and provides foolproof and shockproof operation. A gun or hand-tool and associated cables complete the equipment. This hand-tool is small and light. The mechanism is very simple, consisting of a replaceable chuck, press switch and return spring, together with control and welding cable connections.

Capacitor discharge equipment is not competitive with arc-stud welding over the wide range of diameters that may be welded by the arc process, which is really only restricted by the amount of D.C. current that can be made available.



The I.F.L. automatic billet heating furnace

Rhodes up-cutting shear installed at Samuel Fox and Co. Ltd.



In the diameter range of, say, 6 B.A. to ¼ in., however, studs or attachments may be successfully welded to much thinner plate than is the case when conventional arc-stud welding equipment is employed. The question what diameter of stud may be welded to what gauge of plate cannot be answered in tabulated form. It depends on so many factors, such as material (which might be aluminium, copper, stainless steel, etc.), standard of finish required, and whether it is desired to develop the full strength of stud. At present, there are many applications where attachments have to be welded to 22 gauge material, and this is successfully accomplished with no marking of the underside of the plate.

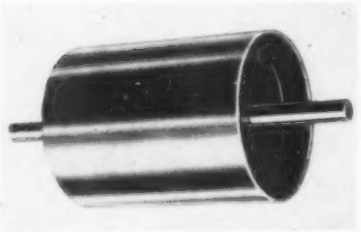
The particular advantage shown by this type of equipment is its ability to run off a single-phase power supply. This is especially valuable on site work, when three-phase current is seldom available and, even when it is, still requires heavy cabling with its attendant expense and restriction on mobility.

Applications also exist in the thicker plate field, where either the arc or C.D. systems would produce satisfactory results. Consideration of the following factors, however, would make C.D. the logical choice: lower initial equipment cost; single phase plug point operation; lower stud cost (no ferrules are used); higher rate of welding; greater versatility as regards stud and plate materials.

Magnetic Separation

A NEW range of "Andox 5" permanent magnet pulleys for extracting tramp iron from processed materials, has been introduced by Rapid Magnetic Limited, Lombard Street, Birmingham. The units incorporate magnets made of anisotropic barium ferrite ceramic material, whose exceptional coercivity permits a radial pole construction as distinct from the axial disposition adopted with Alcomax magnets.

The superior field intensities so produced are equivalent to those of electromagnetic designs, with flux distribution patterned to conform to the burden contour on the belt conveyor. Highest intensity occurs at the centre of the conveyor where burden depth is greatest.



The "Andox 5" permanent magnet pulley for extracting tramp iron

Possessing unusual pulling and holding power and using stainless steel covers for long mechanical life, the pulleys are available in a range of sizes from 12 in. to 24 in. diameter for any belt width.

Permanence is guaranteed for the life of the installation.

MEN and Metals

A director of Imperial Chemical Industries Limited, **Dr. James Taylor** has been appointed to the board of Pyrotenax in succession to **Mr. M. J. S. Clapham,** who has resigned from the board following his recent appointment to the main board of I.C.I.

One of the special features of the Civic Banquet which was given yesterday when **H.R.H. The Duke of Edinburgh** visited Birmingham on the occasion of the Commonwealth Technical Training Week was the speech made by **Robert Morris** on behalf of

the apprentices of Britain. Morris won the award of the "Apprentice of the Year" in 1958 when it was first instituted, and he was then an engineering apprentice at Garringtons Limited. He is now on the permanent staff of the firm and holds the position of assistant to the forge development engineer.

Two appointments have been announced by the Department of Scientific and Industrial Research. The first is an entirely new post of scientific attaché to the British Embassy in Tokyo. **Dr. Charles Manders,** M.A., Ph.D., will advise the British Ambassador on scientific matters and report on Japanese scientific and technical development in the civil field. The new scientific attaché to the British Embassy in Stockholm is to be **Mr. William Drury,** A.M.I.E.E.

News from F. W. Berk and Company Limited is that **Mr. C. H. Tanner,** chairman of the company, left this week for a visit to the United States. **Mr. A. F. Berk,** joint managing director, and **Mr. W. J. Tuffin,** departmental manager of the company, are to visit Madrid and the Almaden Mine, one of the most important sources of quicksilver.

Following his retirement from the board of A. Boake Roberts and Company (Holding), **Mr. F. G. Pentecost** has resigned from the board of Albright and Wilson Limited, and **Mr. B. White** has joined the board of the latter company. **Prof. D. M. Newitt** has been appointed a part-time director of Albright and Wilson.

At the annual general meeting of the Sheffield Cutlery Manufacturers Association last week, **Mr. Ruben Viner** (managing director of the Viner group of companies) was unanimously re-elected President of the Association for the fourth year in succession. Other officers elected were:—Vice-President, **Col. R. Inman;** hon. treasurer, **Mr. A. S. Milburn;** and **Mr. J. Biggin, Mr. Leonard Holmes** and **Mr. W. G. Ibberson** to fill the vacancies on the committee of management.

New appointments to the board of the Consolidated Pneumatic Tool Company Limited have been announced as follows: **Mr. S. H. Ireland** to be assistant managing director, **Mr. L. S. Bright** to be financial director, and **Mr. A. O. Miller,** director.

News from Delaney Gallay Limited is that **Mr. E. R. Perry,** D.F.C., F.I.M., A.C.T., has joined the company as chief metallurgist, and that the metallurgical staff has been further strengthened by **Mr. J. T. H. Harvey,** B.Sc., A.I.M.

It has been announced by the Cambridge Instrument Company Ltd. that **Mr. K. J. Bush,** A.M.I.E.E., has been appointed assistant sales manager of their mechanical thermometer division. **Mr. W. C. Orford, Mr. S. V. J. Crump** and **Mr. W. A. Hall** have been appointed assistant resident engineers at the company's branch offices in Nottingham, Bristol and Manchester respectively.

Appointed general sales manager last year, **Mr. R. H. Wilson** has now been appointed to the board of CIBA (A.R.L.) Limited. He joined the company in 1954 and was initially associated with the development of "Araldite" epoxy resins.

Relinquishing his position as secretary of the company, **Mr. W. H. Day** has been appointed commercial director of the Wellman Smith Owen Corporation. **Mr. D. G. Felton** has been appointed secretary to the company.

Appointed to the board of U.S. Industries Inc. (Great Britain) Limited, **Mr. Charles A. Moore** is also a director of Burtonwood Engineering.

Industrial News *Home and Overseas*

Protective Vinyl Coating

A recent development announced by **Swale Chemicals Limited** is that of an easily strippable protective vinyl coating, type KP/100, for metal and glass. The material can be applied by brushing, spraying, dipping or flow coating. Used primarily to protect the surface of polished metal or plate glass, KP/100 is said to be also suitable as a substitute for strippable tapes in painting and building construction.

It is also stated that this material is tough enough to withstand abrasion, is highly flexible and can be stripped off as a continuous film; is resistant to moisture, common solvents, acids and alkali, oil, detergents, plaster and mortar, and is economical in use.

A Postponement

We are advised by **Sir James Farmer Norton and Company Limited** that, as a result of a recent fire at their works, the bar and tube department was severely damaged and a considerable number of drawings were destroyed. It has been decided that for the time being production of the internal tooth saw for tube cutting machines is to be postponed. This decision is due to the heavy commitments in the bar and tube department caused by the fire.

Works Visit

During the recent annual conference of the Institute of British Foundrymen at Cheltenham, a number of delegates paid a visit to **Newman Industries Ltd.,** at Yate, near Bristol. Split up into four groups, with guides from among executives and from the shop floors, the visitors toured the entire works, as part of the conference programme.

Non-Ferrous Club

At its June luncheon, to be held at the Queen's Hotel, Birmingham, on Wednesday next, June 7, at 12.30 p.m., the **Non-Ferrous Club** is welcoming Superintendent Baumber as its guest speaker. With considerable experience of police work, both of a general and special character, the superintendent should have some interesting things to say.

Members of the club are reminded that the annual golf meeting is being held at Stratford-on-Avon Golf Course at 9.30 a.m. on June 20.

A Removal

It is announced by **Armytage and Sons Ltd.** that they have recently moved their registered office from Sheffield to new offices at Station Road, Whittington Moor, Chesterfield, with the telephone number of Chesterfield 5444. The company is maintaining its Sheffield depot at Park Station.

New Edition

Just published is the 1961 edition of the **British Engineers' Association Handbook,** the annual reference book of the products of the general engineering industry. It is a stoutly bound volume of quarto size, containing over 600 pages, and includes a comprehensive list of products and their manufacturers classified under more than 3,000 headings in English, French, German, Portuguese and Spanish. Copies may be obtained from the association, price 21s.

Metal Strip Coating Plant

A 12 ft. long model of a metal strip coating plant will be displayed at the Interplas exhibition, which is being held at Olympia, in London, this month. It is a scaled-down version of an actual plant over 300 ft. long and will form part of the exhibits on the stand of **Henry Simon Ltd.,** who are to manufacture and market Waldron web processing equipment in Europe by agreement with the Midland-Ross Corporation of the U.S.A.

Metal strip coating plant imparts a decorative and durable finish to the strip metal as part of a continuous process for such items as domestic appliances, office furniture and partitions, trailer caravans, etc. In this process the strip receives thorough cleaning and preparation so that the final coating maintains an intimate bond with the base metal.

New Methods

A new method of fixing Hexmetal, a honeycomb structure made of strip metal in monolithic refractory linings, is said to have resulted in considerable saving in time and labour. With this new method, a preformed mesh of Hexmetal is supplied with lugs of the appropriate length secured in place. The whole assembly can then be anchored to the shell to be lined in one welding operation. Gunning is then carried out in one operation by firing through the mesh.

Hexmetal surface armour is, we understand, being used increasingly for blast furnaces, cyclones, dust collectors, sinter plants and coke bunkers, etc., and the product is made by **Causeway Reinforcement Limited.** The structure protects the lining against thermal and shock stresses and, with heavy monolithic linings, surface pitting and side bulging are prevented.

Copper and Brass Merger

It has been announced by **Enfield Rolling Mills Limited** and the **Delta Metal Company Limited** that negotiations have been concluded for the merger of the rolled copper and brass sheet and strip sections of their respective groups as from July 1 next.

A new company—Delta Enfield Rolled Metals Limited—will be formed to acquire and carry on the combined undertaking, the share capital being held in equal proportions by the two principal companies. None of the other activities of the two companies are affected by the arrangement, nor does it involve the transfer or issue of shares.

I.T.C. Communique

At the close of the **International Tin Council** meeting in London, the issued communique stated: "The Council surveyed the statistical position of tin for 1961 and 1962 and considered the steps which might be taken to deal with the situation indicated by the survey. The next meeting of the Council will be held in London on June 27, 1961". The chairman will not be holding his customary press conference so that no further official information can be expected.

No particular surprise was expressed in metal circles at the negative result of the Council's two-day meeting, writes Comtelburo's metal correspondent. It had been generally felt that there was no pressing justification at the moment for raising the price above the £880 per ton ceiling at which the Buffer Pool Manager must sell. Over the course of this year the estimated deficit in world production over consumption of fully 10,000 tons may well show itself more realistically, but so far the Pool's resources have not been substantially drawn on.

Recent trade estimates were that the Pool still held a tonnage of up to 9,000 tons; prior to sales being made on the London Metal Exchange, it held 10,030 tons. With a sizeable tonnage still available for sale, a higher ceiling would almost certainly be severely criticized by consuming countries generally and the United States in particular. It is evident, however, that the Tin Council is deeply conscious about the future supply and demand position of the metal, hence the need for a further meeting on June 27.

U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week fell 18 tons to 9,172 tons, comprising London 4,229 tons, Liverpool 3,525 tons, and Hull 1,418 tons.

Copper stocks were unchanged at 16,467 tons, distributed as follows: London 600 tons, Liverpool 13,267 tons, Birmingham 50 tons, Manchester 2,450 tons, Hull 50 tons, and Glasgow 50 tons.

Zinc duty-free stocks fell 101 tons to 5,021 tons, comprising London 3,742, Liverpool 779, Glasgow 150, and Manchester 350 tons. In-bond zinc stocks rose 350 tons to 2,196 tons, all in London.

Lead duty-free stocks fell 55 tons to 7,881 tons, comprising London 7,776, Glasgow five, and Swansea 100 tons. Lead in-bond stocks fell 125 tons to 3,718 tons, all in London.

Ward Group Activities

A new booklet, "Talking about Wards", has now been published, which aims to present in the shortest possible manner an outline of the activities of **Thos. W. Ward Ltd.,** and of those other subsidiary and associated companies which together form the Ward Group. Copies are now being made available to all past customers and to prospective ones. The booklet obviously cannot cover every aspect of this complex organization, but it does attempt to give an answer to the many questions likely to be asked in conversations which begin, "Talking about Wards, tell me . . . . ?"

Aluminium Merger Agreement

It is reported that, subject to the approval of the stockholders, the **British Aluminium Company Limited** is to purchase for £10 million the whole of the undertaking of Reynolds T.I. Aluminium Limited other than its holding of stock in British Aluminium.

This has been agreed in order to complete the merger which followed the acquisition of control of British Aluminium two years ago by Tube Investments Limited in association with

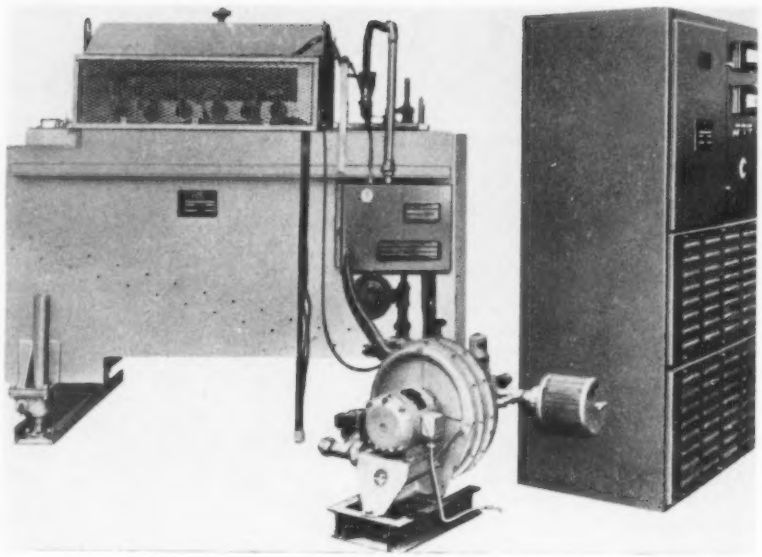
Reynolds Metal Company of America. This will increase the consolidated net assets of British Aluminium from about £42 million to about £52 million

Automatic Ladling of Aluminium

Stated to be the first installation of its kind in this country, a radiant dome aluminium holding furnace fitted with a Lindberg Autoladle, has recently been put into use at the Birmingham works of Aeroplane and Motor Aluminium Castings Ltd. The Autoladle makes fully automatic die-casting possible by dispensing accurate amounts of metal at regular intervals, to a heated launder, for delivery to gravity or pressure die-casting machine. The holding furnace is of American design and was manufactured in this country by **Foundry and Metallurgical Equipment Co. Ltd.**

The furnace, which has a capacity of 2,000 lb., has separate charging and ladling wells and the division between them prevents inclusions from the melting furnace getting into the ladling chamber. The metal is maintained at the required temperature by radiation from non-metallic Globar elements, mounted horizontally above the surface of the metal and easily withdrawn from the side of the furnace. The temperature of the aluminium is controlled automatically.

The Autoladle is submerged in the ladling well and withdraws aluminium from below the surface. It is operated by air-pressure; the quantity of metal it dispenses depends upon the amount of pressure and its duration, and remains constant regardless of the level of the metal. It discharges any quantity of aluminium up to 15 lb. at one minute intervals. Larger models can handle weights up to 60 lb. The holding furnace is made with capacities down to 300 lb.



Fame aluminium holding furnace fitted with an Autoladle and installed in the Birmingham works of Aeroplane and Motor Aluminium Castings Ltd.

Scientific Instruments

A line of long-scale 3-in. edgewise D.C. and A.C. meters has been developed by the American associates of **Honeywell Controls Limited** for use in control console and equipment applications needing reliable indications in severe environments. The new instrument, hermetically sealed, is available in a broad selection of D.C. current (200 micro-amperes and up) and voltage ranges, as well as in rectifier-type A.C. stylus. The mechanism is shielded and the panel has no influence on calibration

The instrument, known as MDE-3, may be mounted horizontally or vertically. Its case size (3·7 by 6·1 by 1·3 in.) makes it possible to mount the meters close together and to obtain in-line read-out.

Aluminium in Japan

Over a month ago the Yawata Iron and Steel Company announced it was planning to start aluminium production jointly with other Japanese firms. It has now stated that the group is negotiating with the Kaiser Aluminum Company of the U.S. for technical assistance and for a capital tie-up. Under the plan, Kaiser Aluminum would hold one-third of the stock of the new company, which would have a capital of £2 million. Yawata Iron and Steel would hold one-third, and the two other companies, the Nisso Steel Manufacturing Company and the Kinoshita Sansho Kaisha, would hold one-third between them

The new company would build a plant in Central or Eastern Japan. By March 1963 the plant was expected to be producing primary aluminium at the rate of 25,000 tons per annum. Production capacity would be expanded to 40,000 tons annually by 1966, Yawata said.

Welding Research

A new 21,000 ft² engineering laboratory at the **British Welding Research Association's** Abington research station is to be formally opened by the Rt. Hon. Lord Mills, P.C., K.B.E., on Wednesday, July 12 next, during the first day of a two-day exhibition of research in progress being staged for industrialists and engineers concerned with the development and application of welding. The new two-storey building will house pressure vessel, brittle fracture, and resistance welding researches, in addition to an extensive machine shop, while the upper floor will provide much-needed office accommodation and conference rooms.

Since B.W.R.A. acquired Abington Hall in 1946, the researches now being transferred have been carried out in the former stables and in ex-army huts. In spite of the difficulties of working under these conditions, the association has been able to sustain a heavy programme of research and to deal with an infinite variety of industrial problems ranging from the study of brittle fracture in heavy steel plate to the welding of catch plates into cooked meat cans.

The need has arisen, however, to initiate several new and important lines of research and to extend considerably the range of available scientific and commercial equipment if the demand for the Association's services is fully to be met over the next few years. In addition to providing proper facilities for the researches specified, the use of the new building will relieve the congestion in the other laboratories and thus enable metallurgical researches to be expanded.

Accidents

The latest edition of the quarterly journal "Accidents—How They Happen", published for the Ministry of Labour, deals with accidents from a wide range of industries. In the chapter devoted to explosions, examples are given of an explosion in a continuous drying oven, and fires and explosions of magnesium.

Another chapter deals with metal industries and quotes such examples as a fatality at a blast furnace, and interlocked covers on sand mixers. Reference is also made to accidents caused to young persons on wire stitching machines. The journal is published on behalf of the Ministry by H.M. Stationery Office at the price of 1s. 3d.

New Ultragraph Recorder

Direct recording of high speed physical phenomena within the frequency range of D.C. to 5,000 c/s is possible with the new ultragraph from the ABEM Company of Stockholm, whose distributors in the U.K. are **Smiths Industrial Division.** Up to fourteen independent channels are available for recording stress, strain, vibration, oscillation, displacement, pressure and temperature changes, or other related events capable of conversion to electrical voltage.

Designed for use in research and industry, the instrument incorporates ultra-sensitive galvanometers, measuring only 75 mm. by 6·5 mm. in diameter which dispense with the need for intermediate amplifiers for many applications. The ultragraph employs a high pressure mercury vapour lamp, and recordings are made on u/v sensitive paper; no processing is required and the traces print out almost immediately.

Quality Control

A full-time course of three weeks' duration on "Statistical Quality Control and Acceptance Sampling", commencing on Monday, September 11 next, is being offered by the **College of Advanced Technology, Birmingham.**

The course is primarily intended as an introduction to the subject. Nevertheless it provides the basic training necessary for quality control engineers.

The first fortnight will be spent in covering the general principles and procedures of quality control. The final week will be devoted to lectures by specialists from industry, and to visiting the works of firms employing quality control, where members of the course will be able to see the practical application of quality control methods, and discuss the techniques and associated problems.

The course will be directed by Mr. J. D. Morrison, principal lecturer in metrology and quality control in the production engineering department, and will be run in co-operation with the mathematics department. Further details and application forms can be obtained from the Bursar, College of Advanced Technology, Gosta Green, Birmingham, 4.

Chinese Antimony Metal

According to reports in London metal circles, Chinese 99·6 per cent antimony metal is now available at £181 per metric ton c.i.f. United Kingdom. This compares with a price of £186 recently. The reduction was not altogether surprising as buyers had been unwilling to pay £186 when it was substantially raised to that level following the £20 per long ton increase in the United Kingdom price on April 1. Moreover, one market source thinks the Chinese want to sell and that possibly a serious buyer could obtain metal at below £181.

On a delivered United Kingdom basis the 99·6 per cent price would be equivalent to about £230 per long ton after including the 25 per cent import duty on foreign metal entering this country and conversion to a long ton. The United Kingdom price for domestically produced 99·6 per cent metal is £237 10s. 0d. per long ton delivered. For Chinese 99 per cent metal—a price has been unobtainable for some time—£176 per metric ton c.i.f. United Kingdom is indicated.

Metallurgists Relax

Taking up a challenge from the Birmingham Local Section of the Institute of Metals, the Birmingham Metallurgical Society mustered a skittles team this week, when they met their opponents at the White Swan, Harborne, for the first match between the two societies. After being in the lead throughout the first five games, the B.M.S. team was defeated in the last, the score being: Institute of Metals Local Section—382, Birmingham Metallurgical Society—361.

The match proved a very successful innovation, and a return challenge is expected later in the year.

Trade with Russia

According to reports from Moscow, **Enfield Rolling Mills Ltd.** have secured a valuable contract at the British Trade Fair being held there. The order concerns the supply of unwrought copper for a Russian company, and the value of the order is said to be in the region of £450,000.

Careers Exhibition

In connection with the Commonwealth Technical Training Week, a Careers Exhibition is being held this week at Bingley Hall, Birmingham, where the **Engineering Centre** is staffing a stand representing a number of companies interested in apprenticeship and training schemes.

Among the companies represented on this stand are Thomas Chatwin and Company (Birmingham), Alfred Herbert Limited (Coventry), The Delta Metal Company Limited (Birmingham), Clifford Machine Tools Limited, Compression Joints Limited, Cornercroft Limited, and Coley Bros. (Tools) Limited, all of Birmingham.

Complementary to the Bingley Hall exhibition is a "Linking for Skill" exhibition which has been put on at the Engineering Centre by the Engineering Industries Association Group Apprenticeship. It features the work of the Midlands' apprentices in various engineering industries, and an apprentices' competition was organized to lend added interest to the event.

Copper Tube Bender

Recently introduced by **Chamberlain Industries Ltd.** is a 2 in. capacity portable hydraulic copper tube bender. This is a powerful and compact unit requiring the very minimum floor space of only 3 ft², while the position of the pump handle, immediately above the hydraulic self-contained hand pump, enables the operator to apply his weight to each downward stroke, thereby minimizing operating effort and eliminating horizontal pulling and wrenching movements.

The makers state that right-hand and left-hand bends can be made without restriction, and offset bends and sets, etc., can be produced with a minimum of length of straight between the bends, resulting in neat and economical work. The price of this new unit is stated to be £67 15s. 0d., complete with all tools to bend ½ in. to 2 in. copper tube. Additional sets of formers for bending gas pipe, electrical conduit or light gauge ferrous and non-ferrous tubes can be purchased separately or as an alternative to the standard formers.

Light Metal Statistics

Figures showing the U.K. production, etc., of light metals for March 1961 have been issued by the Aluminium Industry Council as follows (in long tons):—

Virgin Aluminium	
Production	2,688
Imports	16,930
Despatches to consumers	15,735
Secondary Aluminium	
Production	10,825
Virgin content of above	1,166
Despatches (including virgin content)	11,055
Scrap	
Arisings	13,410
Estimated quantity of metal recoverable	9,838
Consumption by:	
(a) Secondary smelters	13,044
(b) Other uses	1,068
Despatches of wrought and cast products	
Sheet, strip and circles	14,235
Extrusions (excluding forging bar, wire-drawing rod and tube shell):	
(a) Bars and sections	3,897
(b) Tubes (i) extruded	328
(ii) cold drawn	743
(iii) formed strip	—
(c) (i) Wire	1,635
(ii) Hot rolled rod (not included in (c) (i))	118
Forgings	379
Castings: (a) Sand	1,743
(b) Gravity die	4,470
(c) Pressure die	1,792
Foil	2,192
Paste	306

Zone-Refined Tellurium

An announcement from **Johnson, Matthey and Company Ltd.** states that they are now producing zone-refined tellurium of high purity. The total metallic impurity content, excluding selenium, is less than 5 p.p.m. and is normally in the region of 1 p.p.m. The selenium content does not exceed 5 p.p.m.

Johnson, Matthey tellurium is supplied as half-round bar, approximately 1 in. by ½ in. Further particulars are available on application to the company.

Commonwealth Technical Training Week

From the **British Oxygen Company Ltd.** we learn that the company is playing an active part in this special week. The company is participating in special exhibitions throughout the country, organizing displays and demonstrations in schools and technical colleges, and arranging for groups of young people to visit its plants.

Two 20-year-old apprentices, one from Enfield, Middx., the other from Wellington, New Zealand, are on an exchange visit as part of the contribution by the company to the Commonwealth Technical Training Week. The British apprentice, who is taking a production engineering sandwich course at the company's engineering training school at Edmonton, flew from London to Wellington last week.

The New Zealander is a technical apprentice with New Zealand Industrial Gases Ltd., a member of the British Oxygen group.

Orders from W. Germany

News from Bournemouth is that the **Loewy Engineering Company Limited** has received orders from West Germany to the value of £500,000 for three extrusion presses for the production of tubes and profiles; the presses will be supplied with Loewy - Magnethermic induction billet heaters.

News from Birmingham

Due mainly to the improvement in the motor trade, unemployment has been cut in the Birmingham area to 1 per cent, the level at which it stood last autumn before the car industry recession. A month ago it was 2·15 per cent. The biggest improvement has been among the total temporarily stopped or workers on short time but entitled to unemployment benefit. Demand for engineering and electrical goods is much higher than a year ago, and orders for plant and machinery have expanded since the beginning of the year. There is a strong demand for metal fittings used in the building industry.

Production of iron castings continues to improve although it has not yet reached the high figures attained this time last year. The motor trade and the general engineering industries are responsible for a good flow of orders to Midland foundries. Makers of steel sheets are delivering bigger tonnages to consumers. There is a strong demand for structural steel, and considerable activity amongst producers

of machine tools. A wider range of steel products is passing through the rolling mills making it easier to obtain early delivery.

Anti-Static Boot

A new type of boot, capable of dispelling static build-up, was demonstrated on the stand of **Thos. W. Ward Ltd.,** at the recent Ro.S.P.A. exhibition held at Scarborough. This footwear should be of particular interest to such industries as petroleum, chemical explosives, etc., where extra safety against highly inflammable materials is required. It is stated to be oil-resistant.

Aluminium Bungalows

It is reported that an order for more than 100 aluminium bungalows has been placed by the Ministry of Education for Northern Nigeria with **Coseley Buildings.** The value of the order is said to be in the region of £360,000. It is understood that the bungalows are for the use of teachers in Nigeria.

This order is said to be the largest yet received by the company for these bungalows. Coseley has been steadily building up trade in Nigeria for the last eight years.

Non-Destructive Testing

Early advance notice is given of the Summer Conference on Non-Destructive Testing, which is to be held this year from September 21 to 23 at the Blossoms Hotel, Chester. The Conference is being organized by the **Non-Destructive Testing Society,** and the theme this year is to be "Industrial Radiology Today", and it is intended to base the papers and discussion on the application of newly developed aspects of industrial radiology.

The papers will include such subjects as low kV radiography, Xeroaudography, linear accelerators, Betatrons, large gamma ray sources for radiography and current safety regulations.

World Tin Statistics

World mine production of tin-in-concentrates is estimated to have fallen from 14,400 tons in December to 12,400 tons in January, the International Tin Council said in its statistical bulletin for April. World production in February can be provisionally estimated at 11,500 tons. World smelter production of tin metal is estimated to have risen from 14,300 tons in December to 14,700 tons in January.

The bulletin said world consumption of primary tin metal rose from 14,300 tons in December to 15,700 tons in January. Consumption in West Germany during January has been provisionally estimated at 3,000 tons, compared with a monthly average of 2,535 tons during the last quarter of 1960. Consumption of primary tin in the United States rose from 2,845 tons in December to 3,680 tons in January; in February, it declined slightly to 3,570 tons. There was also a slight decline in consumption in the United Kingdom in February.

Stock of tin-in-concentrates at mine, in transit and at smelters in Malaya and Singapore fell from 7,576 tons at the end of December to 6,146 tons at the end of January. Stocks in Nigeria showed almost no change in the first two months of 1961, but there was some increase in stocks in Thailand. End-January figures for Bolivia and Indonesia have not yet been reported.

Stocks of tin metal with consumers in the U.S. showed little change at the end of January (21,070 tons) but fell to 19,605 tons a month later. Stocks at official warehouses in the United Kingdom showed a further small increase at the end of March.

Estimated world output of tinplate rose sharply from 505,000 tons in December to 765,000 tons in January. The improvement was almost entirely the result of the very steep increase in shipments in the United States, which more than doubled from 229,000 tons to 479,000 tons. Production in other countries, taken together, showed only a small increase. In February, shipments in the United States fell to 379,000 tons. The Council emphasized that all world figures exclude the U.S.S.R.

Chilean Copper

A report published recently by the Chilean Copper Department states that between 1955 and 1960 the primary production of copper in Chile amounted to an average of 491,000 tons yearly. Production in 1960 totalled 532,393 metric tons. The Department states that before it was created in order to supervise Chilean copper mining production, output was much lower, averaging 376,000 metric tons yearly during 1950 to 1954. "Producing and consuming sectors", the report says, "agree that if the commercialization of copper develops favourably, world consumption of the metal will increase by a minimum of 40 per cent during the next 10 years.

"Among the necessary circumstances, in the opinion of the Department, are an adequate price within comparative stability; promotion of current copper uses; and the research for new applications, as well as the distribution of the metal in the quantities and refining qualities required by the consumer market."

The report also states that the Government, through the National Mining Enterprise (Empresa Nacional de Mineria) plans to construct a smelter and refinery for copper in the central zone of Chile. Concluding, the Department says it has issued an official invitation to the International Council for Non-Ferrous Metals for the next joint meeting of producers and consumers taking place during the first quarter of 1962, to be held in Santiago, Chile.

Mining in New Guinea

According to reports from The Hague, the Second Chamber (Lower House) of the Dutch Parliament last week approved a Bill authorizing the Government to conclude a 75 year contract with a Dutch-American company for the exploration and exploitation of minerals and ores in Netherlands New Guinea. The company will be jointly established by the Oost Borneo Maatschappij NV of Amsterdam, the Nederlandsche Handel Maatschappij NV of Amsterdam, Wm. H. Meuller and Co. NV, of Rotterdam, the United States Steel Corporation of Pittsburgh and the Navigen Company of Nassau, Bahama Islands. The Bill will now go to the Upper House for final approval.

Under the contract, the company will get concessions for the exploration and exploitation of iron, nickel, cobalt, chromium, manganese, pyrite, platinum, gold and silver bearing ores and minerals in the Cyclope Mountains, a large area of Waigejo and a number of small islands belonging to New Guinea. The ores and minerals will be processed in New Guinea if possible.

The State Secretary for New Guinea, Mr. T. Bot, told the Chamber additionally that explorations for copper in the Karstens Mountains had been successful.

Company Reports

Amber Chemical

Group profit, 1960, £17,825 (£7,464), subject to tax £9,790 (credit £1,554). To minority interests £1,742 (£965), Preference dividend for 1957 £3,063 (£6,125), further loss on sale of subsidiary £2,535 (£5,409). Adverse balance forward in subsidiaries' accounts £49,521 (£50,216). Current assets £156,579 (£123,782) and liabilities £98,555 (£58,620). It is proposed to pay a year's Preference arrears on June 30, and it is hoped to pay a further year's dividend in December.

Consolidated Zinc Corporation

Net profit, 1960, £2,295,660 (£2,663,267), and dividend 4s. (same) per £1 share. Fixed assets £22,198,690 (£16,871,424). Investments and advances £9,584,274 (£8,104,087). Current assets £17,171,029 (£20,615,905), liabilities £6,959,819 (£5,934,833).

New Companies

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

A. S. Blackham (Metals) Limited (690196), 105 Pinfold Lane, Penn, Wolverhampton. Registered April 19, 1961. To take over business of a metal merchant carried on by A. S. Blackham, etc. Nominal capital, £2,000 in £1 shares. Directors: Alfred Blackham and Fredk. W. Blackham.

Interalloys Limited (690739), 23 Dering Street, W.1. Registered April 25, 1961. To carry on business of dealers in and merchants of iron, steel, copper, bronze, aluminium, etc. Nominal capital, £1,000 in £1 shares. Directors: Ludwig Mandel, John A. Marsh and Laurence N. Roe.

Ashley Precision (Parkstone) Limited (690834), 24 Wessex Road, Parkstone, Dorset. Registered April 26, 1961. To carry on business of metal and alloy makers, etc. Nominal capital, £2,000 in £1 shares. Directors: Norman Wright, Eric S. Thomas, Gordon T. E. Forsey and James Finlayson.

J.B. Demolition Limited (691071), 7 Clytha Crescent, Newport, Mon. Registered April 28, 1961. To carry on the business of buyers of and dealers in scrap metals, machinery, tools, etc., Nominal capital, £5,000 in £1 shares. Directors: John J. Buttigieg and Joan M. Buttigieg.

Albaston Limited (691249), 6 Surrey Street, W.C.2. Registered May 1, 1961. To carry on business of machinery and metal merchants, etc. Nominal capital, £100 in £1 shares. Directors to be appointed by subscribers.

Radcliffe Brass Foundry Limited (691312), Bridgefield Street, Radcliffe, Lancs. Registered May 2, 1961. Nominal capital, £1,500 in £1 shares. Directors: Hector McDonald and Florence McDonald.

S. A. Watts & Co. Limited (691327), 781 Hertford Road, Enfield, Middlesex. Registered May 2, 1961. To carry on business of metal polishers, painters, etc. Nominal capital, £1,000 in £1 shares. Directors: Sydney A. Watts and Margaret G. K. Watts.

Metal Market News

SHARP SETBACK IN COPPER QUOTATION — COPPER AND ZINC STOCKS BUILD UP — TIN MARKET REMAINS STEADY

THE feature of last week's trading on the Metal Exchange was the collapse in the copper quotation on Thursday and Friday, when the Kerb quotation stood at nearly £6 below the high point for the week achieved on Wednesday, when cash stood at £249 and three months at £249 15s. 0d. Thursday's Comex quotation in the States was down by 50 points, whereas at the beginning of the week Tuesday saw the New York futures market some 75 points up since the previous Friday. Before the break came, a price of 32½ cents for some custom smelter copper was reported, and it was confidently commented that the copper price was heading for 33 cents. The strength of the market was largely due to the El Teniente strike and the trouble at Chilean ports, and when a report came through on Thursday that the dock strike was settled and that there was a good chance of the dispute at the mine being resolved over the week-end, the market turned easy. Stocks in official warehouses of the L.M.E. were reported at the beginning of the week as follows: copper 400 tons up at 16,467 tons; tin 144 tons lower at 9,190 tons; lead 100 tons down at 11,779 tons; zinc 390 tons up at 6,968 tons. It is certainly encouraging that stocks of copper continue to build up so satisfactorily and zinc reserves also are on the upward path. The contango in copper widened and at the end of the week stood at 35s., an altogether satisfactory development.

The Exchange did not open until Tuesday morning in view of the Whitsun holiday, so that in the shortened trading period a turnover of 14,000 tons of copper was reasonably good. As already mentioned, there was a sharp setback in the quotation during the second half of the week, and at Friday midday the settlement price had dropped to £243 10s. 0d., while the forward quotation was £245. On the Kerb, business was done 5s. lower, but in the afternoon a modest rally occurred to £243 15s. 0d. cash and £245 10s. 0d. three months. On balance, cash lost £1 and three months 5s. In spite of the setback last week, opinion about the outlook for the price remains rather bullish, and at the close of business on Friday the feeling was the setback had pretty well spent itself. At the same time, it is realized that order books in the semis industry are in some directions rather thin, for new business has not been coming in at a rate to match deliveries. For this state of affairs some people blame the relatively high level of the copper quotation and it is, of course, a fact that both brass and copper products, especially perhaps the former, are nowadays threatened with a good deal of competition by way of substitution.

There has been no hint from the producers that they intend to restore the cuts made in the autumn, and so far Kennecott is the only company that has returned to normal working. In the light of the April statistics it is hard to see how curtailment can now be justified. The statement issued by the Tin Council did not give any pointer about future policy, and the tin market has remained steady. In the four days trading some 700 tons changed hands, cash closing £2 10s. 0d. up at £870 10s. 0d., and three months £3 10s. 0d. better at £875. Lead was weak, losing £1 12s. 6d. for cash at £65, and 30s. three months at £66 7s. 6d. The turnover was 6,700 tons. After a turnover of 6,400 tons, zinc closed 2s. 6d. down for cash at £81 15s. 0d. and unchanged forward at £82 5s. 0d.

New York

Quieter conditions prevailed in the non-ferrous metals market on Monday last, due to a smaller attendance of dealers on the long holiday week-end. There was no trading in non-ferrous metal futures because of the extended closing of the New York Commodity Exchange for the Memorial Day holiday. In copper, custom smelters reported modest business, mostly at the monthly average. Producers were moving routine material.

Prices of scrap copper were a shade softer. One large custom smelter cut the buying price by ¼ of a cent a lb. Other smelters followed later in the day and the 27.50 cent level is now fairly general. Lead and zinc were quiet. Tin was slow to move but prices were slightly better.

The Titan Metal Manufacturing Company division of Cerro Corporation announced a 1 cent per lb. increase in base prices for its free cutting and forging brass rod, effective June 1, 1961. The new base price for free cutting rod will be 35·77 cents per lb. Titan's prices for other rod products and its purchase price for brass scrap will remain unchanged.

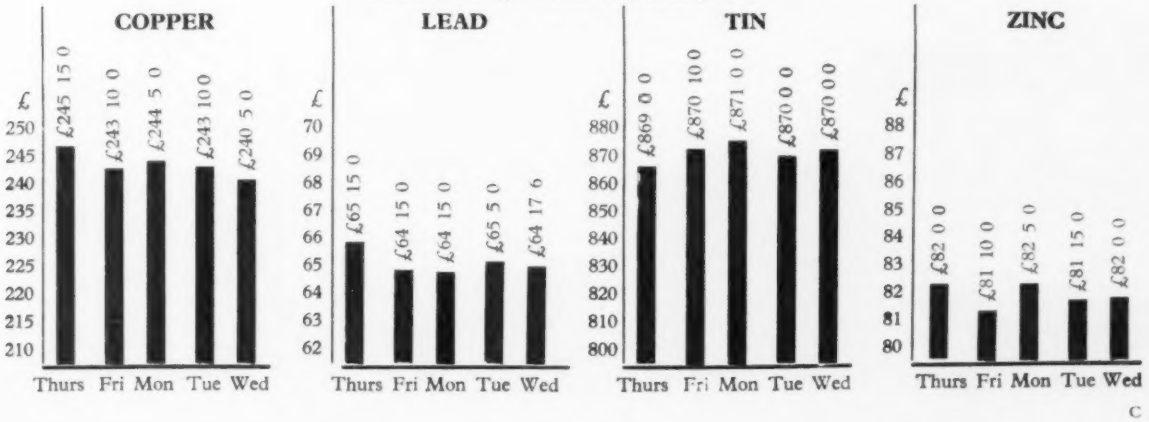
New from Washington is that the House Interior Committee has announced that it will hold a public hearing on lead-zinc legislation on June 16. The hearings will be concerned only with the legislation which calls for a subsidy for producers of the metals under 2,000 tons per year.

Paris

Steady to firm conditions ruled on the Paris scrap market in the week ended on May 25 in fairly active trading. Copper prices gained some ground under the influence of favourable foreign advices while bronze benefited again from a good level of demand. Lead and zinc were very steady. Aluminium remained very quiet.

London Metal Exchange

Thursday 25 May to Wednesday 31 May 1961



C

NON-FERROUS

PRIMARY METALS

All prices quoted are those available at 2 p.m. 31/5/61

		£	s.	d.
Aluminium Ingots	ton	186	0	0
Antimony 99·6%	,,	237	10	0
Antimony Metal 99%	,,	230	0	0
Antimony Oxide Commercial	,,	194	10	0
Antimony White Oxide	,,	212	0	0
Arsenic	,,	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	,,		11	0
Calcium	,,	2	0	0
Cerium 99%	,,	15	0	0
Chromium	,,		6	11
Cobalt	,,		12	0
Columbite per unit			8	10	0
Copper H.C. Electro	ton	240	5	0
Fire Refined 99·70%	,,	239	0	0
Fire Refined 99·50%	,,	238	0	0

		£	s.	d.
Copper Sulphate	ton	81	0	0
Germanium	g.m.		—	
Gold	oz.	12	11	3
Indium	,,		10	0
Iridium	,,	24	0	0
Lanthanum	grm.		15	0
Lead English	ton	64	17	6
Magnesium Ingots	lb.			
99·8%	,,		2	2½
99·9+%	,,		2	3
Notched Bar	,,		2	9½
Powder Grade 4	,,		5	6
Alloy Ingot, AZ91X		1	11½-2	1¼
Manganese Metal	ton	280	0	0
Mercury	flask	67	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	,,		5	6
Osmium	oz.	20	0	0
Osmiridium	,,		—	

		£	s.	d.
Palladium	oz.	9	0	0
Platinum	,,	30	5	0
Rhodium	,,	46	0	0
Ruthenium	,,	16	0	0
Selenium	lb.	2	6	6
Silicon 98%	ton	123	0	0
Silver Spot Bars	oz.		6	7¾
Tellurium Sticks	lb.	2	0	0
Tin	ton	870	0	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	,,		—	
Virgin Min 98%	,,	82	2	6
Dust 95·97%	,,	125	0	0
Dust 98·99%	,,	131	0	0
Granulated 99+%	,,	107	2	6
Granulated 99·99+%	,,	121	17	6

**Duty and Carriage to customers' works for buyers' account.*

INGOT METALS

All prices quoted are those available at 2 p.m. 31/5/61

Aluminium Alloy (Virgin)		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	,,	202	0	0
B.S. 1490 L.M.7	,,	216	0	0
B.S. 1490 L.M.8	,,	203	0	0
B.S. 1490 L.M.9	,,	203	0	0
B.S. 1490 L.M.10	,,	221	0	0
B.S. 1490 L.M.11	,,	215	0	0
B.S. 1490 L.M.12	,,	223	0	0
B.S. 1490 L.M.13	,,	216	0	0
B.S. 1490 L.M.14	,,	224	0	0
B.S. 1490 L.M.15	,,	210	0	0
B.S. 1490 L.M.16	,,	206	0	0
B.S. 1490 L.M.18	,,	203	0	0
B.S. 1490 L.M.22	,,	210	0	0
Aluminium Alloys (Secondary)				
B.S. 1490 L.M.1	ton	160	0	0
B.S. 1490 L.M.2	,,	161	0	0
B.S. 1490 L.M.4	,,	170	0	0
B.S. 1490 L.M.6	,,	176	0	0
***Aluminium Bronze**				
BSS 1400 AB.1	ton	257	0	0
BSS 1400 AB.2	,,	265	0	0

***Brass**		£	s.	d.
BSS 1400-B3 65/35	ton	185	0	0
BSS 249	,,		—	
BSS 1400-B6 85/15	,,	233	0	0
***Gunmetal**				
R.C.H. 3/4% ton	,,		—	
(85/5/5/5) LG2	,,	231	0	0
(86/7/5/2) LG3	,,	241	0	0
(88/10/2/1)	,,	295	0	0
(88/10/2/½)	,,	305	0	0
***Manganese Bronze**				
BSS 1400 HTB1	,,	203	0	0
BSS 1400 HTB2	,,	221	0	0
BSS 1400 HTB3	,,	240	0	0
Nickel Silver				
Casting Quality 12%	,,	260	0	0
,, ,, 16%	,,	270	0	0
,, ,, 18%	,,	310	0	0
***Phosphor Bronze**				
B.S.1400P.B.1.(A.I.D. released)	,,	323	0	0
B.S. 1400 L.P.B.1	,,	254	0	0

**Average prices for the last week-end.*

Phosphor Copper		£	s.	d.
10%	ton	273	0	0
15%	,,	275	0	0
Phosphor Tin				
5%	,,	951	0	0
Silicon Bronze				
BSS 1400-SB1	,,	293	0	0
Solder, soft, BSS 219				
Grade C Tinmans	,,	396	5	0
Grade D Plumbers	,,	315	10	0
Grade M	,,	436	10	0
Solder, Brazing, BSS 1845				
Type 8 (Granulated)	lb.		—	
Type 9	,,		—	
Zinc Alloys				
BSS 1004 Alloy A	ton	115	7	6
BSS 1004 Alloy B	,,	119	7	6
Sodium-Zinc	lb.		2	7

SCRAP METALS

Merchants' average buying prices delivered, per ton, 30/5/61

Aluminium	£
New Cuttings	138
Old Rolled	103
Segregated Turnings	78
Brass	
Cuttings	170
Rod Ends	152
Heavy Yellow	145
Light	140
Rolled	159
Collected Scrap	143
Turnings	145

Copper	£
Wire	220
Firebox, cut up	218
Heavy	217
Light	213
Cuttings	225
Turnings	197
Braziery	187
Gunmetal	
Gear Wheels	210
Admiralty	210
Commercial	194
Turnings	189

Lead	£
Scrap	56
Nickel	
Cuttings	—
Anodes	554
Phosphor Bronze	
Scrap	194
Turnings	189
Zinc	
Remelted	75
Cuttings	67
Old Zinc	45

METAL PRICES

SEMI-FABRICATED PRODUCTS

Prices vary according to dimensions and quantities. The following are the basis prices for certain specific products

		£ s. d.
Aluminium		
Sheet 10 S.W.G.	lb.	2 10½
Sheet 18 S.W.G.	,,	3 0½
Sheet 24 S.W.G.	,,	3 3½
Strip 10 S.W.G.	,,	2 10½
Strip 18 S.W.G.	,,	2 11½
Strip 24 S.W.G.	,,	3 1
Circles 22 S.W.G.	,,	3 4½
Circles 18 S.W.G.	,,	3 3½
Circles 12 S.W.G.	,,	3 2½
Plate as rolled	,,	2 10
Sections	,,	3 4
Wire 10 S.W.G.	,,	3 1½
Tubes 1 in. o.d. 16 S.W.G.	,,	4 4
Aluminium Alloys		
BS 1470. HS19W.		
Sheet 10 S.W.G.	,,	3 3
Sheet 18 S.W.G.	,,	3 5½
Sheet 24 S.W.G.	,,	4 1
Strip 10 S.W.G.	,,	3 3
Strip 18 S.W.G.	,,	3 4½
Strip 24 S.W.G.	,,	4 0½
BS1477. HP30M. Plate as rolled	,,	3 1
BS1470. HC15WP.		
Sheet 10 S.W.G.	,,	4 3
Sheet 18 S.W.G.	,,	4 8½
Sheet 24 S.W.G.	,,	5 8½
Strip 10 S.W.G.	,,	4 4
Strip 18 S.W.G.	,,	4 8½
Strip 24 S.W.G.	,,	5 4½

		£ s. d.
Aluminium Alloys—cont.		
BS1477. HPC15WP. Plate heat treated	lb.	3 10½
BS1475. HG19W. Wire 10 S.W.G.	,,	4 2
BS1471. HT19WP. Tubes 1 in. o.d. 16 S.W.G.	,,	5 5
BS1476. HE19WP. Sections	,,	3 4
Split tube		
19 S.W.G. (⅛")	,,	4 2
20 S.W.G. (⅜")	,,	3 11
21 S.W.G. (⅜")	,,	4 1
22 S.W.G. (¼")	,,	4 11
Welded tube 14 to 20 S.W.G. (sizes ½" to 1½")	,,	3 10½ to 5 8½
Brass		
Tubes	lb.	1 11⅜
Brazed Tubes	,,	3 3⅜
Drawn Strip Sections	,,	3 3⅜
Sheet	ton	209 5 0
Strip	,,	209 5 0
Extruded Bar	lb.	2 1¼
Condenser Plate (Yellow Metal)	ton	200 0 0
Condenser Plate (Naval Brass)	,,	213 0 0
Wire	lb.	2 9½

		£ s. d.
Beryllium Copper		
Strip	lb.	1 4 11
Rod	,,	1 1 6
Wire	,,	1 4 9
Copper		
Tubes	lb.	2 5¼
Sheet	ton	278 15 0
Strip	,,	278 15 0
H.C. Wire	,,	295 15 0
Cupro Nickel		
Tubes 70/30	lb.	3 8
Lead		
Pipes (London)	ton	107 0 0
Sheet (London)	,,	104 15 0
Tellurium Lead	,,	£6 extra
Nickel Silver		
Sheet and Strip 10%	lb.	3 11¾
Wire 10%	,,	4 4¼
Phosphor Bronze		
Wire	,,	4 3⅛
Titanium (1,000 lb. lots)		
Billet 4½" to 18" dia.	lb.	47/- 48/-
Rod ¼" to 4" dia.	,,	85/- 53/-
Wire ·036"-232" dia.	,,	159/- 99/-
Strip ·001" to ·048"	,,	350/- 68/-
Sheet 8' × 2'. 20 gauge	,,	73/-
Tube, representative average gauge	,,	198/-
Extrusions	,,	90/-
Zinc		
Sheet	ton	120 2 6
Strip	,,	nom.

FOREIGN QUOTATIONS

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

Belgium	fr kg	£ ton
Copper: electrolytic	33.75	246 13
Tin	121.75	889 17

Canada	c lb	£ ton
Aluminium	26.00	210 12
Copper: electrolytic	30.00	243 0
Lead	10.00	81 0
Nickel	70.00	567 0
Zinc: Prime western	12.25	100 4
High grade 99.95	12.85	104 17
High grade 99.99	13.25	107 6

France	fr kg	£ ton
Aluminium	2.43	179 11
Antimony 99·0	2.80	206 18
Cadmium	16.25	1,200 17
Copper: electrolytic	3.39	250 10
Lead	.97	71 13
Nickel	9.00	665 2
Tin	12.38	914 17
Zinc: Thermic	1.20	88 13
Zinc: electrolytic	1.28	94 11
Scrap		
Copper: electrolytic	3.03	223 18
Heavy copper	3.03	223 18
No. 1 copper wire	2.85	210 12
Brass rod ends	2.90	214 6
Zinc castings	.98	72 8
Lead	.92	67 19
Aluminium	1.70	125 12

Italy	lire kg	£ ton
Aluminium	1,370	216 1
Antimony 99·0	520	303 13
Copper: wire bars 99.9	470	347 6
Lead	167	98 10
Nickel	1,180	689 2
Tin	1,620	956 1
Zinc: electrolytic	185	108 0
Scrap		
Aluminium soft sheet clippings (new)	305	178 2
Lead, soft, first quality	140	81 15
Lead, battery plates	80	46 14
Copper, first grade	395	230 13
Bronze, commercial gunmetal	350	204 8
Brass: heavy	285	166 8
Brass: light	270	157 12
Brass, bar turnings	285	166 8
Old zinc	108	63 0

Switzerland	fr kg	£ ton
Aluminium	2.50	210 5
Copper: electrolytic	2.88	242 4
Lead	.80	67 5
Nickel	7.50	630 15
Tin	10.30	866 4
Zinc: High grade 99.99	1.05	88 6

Japan Yen per metric ton	
Scrap	
Copper: electrolytic	295,000
Copper wire No. 1	272,000
Copper wire No. 2	257,000
Heavy copper	257,000
Light copper	225,000
Brass, new cuttings	209,000
Red brass scrap	215,000

West Germany *Scrap*	D-marks per 100 kilos	£/ton
Used copper wire	238	216 16
Heavy copper	238	216 16
Light copper	210	191 6
Heavy brass	150	136 13
Light brass	120	109 6
Soft lead	58	52 16
Zinc	60	54 12
Used aluminium unsorted	90	81 19

United States	c lb	£ ton
Aluminium	26.00	207 4
Antimony 99·0	32.50	259 0
Cadmium	160.00	1,275 4
Copper: electrolytic	31.00	247 10
Lead	11.00	87 13
Nickel	74.00	589 15
Tin	111.12	886 4
Zinc: electrolytic	12.50	98 12

THE STOCK EXCHANGE

Firm Undertone For Start Of New Account

ISSUED CAPITAL *	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 29 MAY +RISE—FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1961 HIGH	1961 LOW	1960 HIGH	1960 LOW
£	£			Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	33/-	11	9	6 13 3	33/9	26/3	35/-	26/6
400,000	2/-	Anti-Attrition Metal	1/3	NIL	4	NIL	1/3½	0/9	1/6	0/9
43,133,593	Stk. (£1)	Associated Electrical Industries ...	42/9 —6d.	15	15	7 0 3	54/10½	40/3	67/3	38/3
3,895,963	1	Birfield	71/3xd —2/-	10	15‡	2 16 3	78/9	45/-	51/3	29/-
4,795,000	1	Birmid Industries	98/6 +3/6	20	20D	4 1 3	103/-	71/3	74/9	56/-
8,445,516	Stk. (10/-)	Birmingham Small Arms	30/6xd —3/3	17½QT	12½	3 16 6	36/10½	24/9	30/6	18/3
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	14/6	5	5	6 18 0	14/6	13/9	17/4½	14/9
476,420	Stk. (£1)	Ditto Cum. B. Pref. 6%	17/-	6	6	7 1 3	17/6	16/9	20/-	17/1½
500,000	1	Bolton (Thos.) & Sons	58/9	12½	10	4 5 3	57/6	37/6	43/-	36/-
300,000	1	Ditto Pref. 5%	16/6	5	5	6 1 3	16/6	13/9	16/-	14/3
1,500,000	Stk. (£1)	British Aluminium Co. Pref. 6% ...	17/-	6	6	7 1 3	18/-	16/6	21/1½	17/7½
18,846,647	Stk. (£1)	British Insulated Callender's Cables	60/- +1/9	13½	13½	4 10 0	62/-	50/4½	61/4½	47/-
20,456,599	5/-	British Oxygen Co. Ltd., Ord. ...	24/9xcap —1/-	16D	16	2 3 3	28/4½	17/6	35/-	19/10½
1,200,000	Stk. (5/-)	Canning (W.) & Co.	16/4½	15⅝	25 + *2½C‡	4 14 0	20/9	13/7½	19/9	13/7½
60,484	1/-	Carr (Chas.)	10½d. —3d.	NIL	12½	—	1/7½	10½d.	2/3	1/-
555,000	1	Clifford (Chas.) Ltd.	30/- +6d.	12	10	8 0 0	29/6	26/-	35/-	28/9
45,000	1	Ditto Cum. Pref. 6%	15/3	6	6	7 17 6	15/3	15/1½	16/-	15/10½
300,000	2/-	Coley Metals	4/-	15	15	7 10 0	4/5½	3/6	5/-	3/4½
10,185,696	1	Cons. Zinc Corp.†	75/9 2/9	20	15	5 5 9	81/6	64/-	80/9	59/6
5,399,056	1	Davy-Ashmore	173/9 —2/3	30‡	20	1 13 3	177/6	129/6	147/3	99/6
8,000,000	5/-	Delta Metal	26/7½ —4½d.	20	17½	3 15 0	27/7½	19/9	28/3	18/6
5,296,550	Stk. (£1)	Enfield Rolling Mills Ltd. ...	45/9	15	15	6 11 0	52/3	45/-	56/9	45/-
1,155,000	1	Evered & Co.	45/- +6d.	10B	10φ	2 19 3	45/-	42/6	42/9	29/3
18,000,000	Stk. (£1)	General Electric Co.	36/9 —6d.	10	10	5 8 9	39/6	29/6	47/9	29/-
1,500,000	Stk. (10/-)	General Refractories Ltd.	62/3 —6d.	25	20	4 0 6	65/-	42/9	52/6	40/-
937,500	5/-	Glacier Metal Co. Ltd.	20/-	15	13	3 15 0	21/1½	13/9	16/1½	11/1½
2,500,000	5/-	Glynwed Tubes	30/3 +1/-	22½	25¶	3 14 6	30/-	23/7½	27/6	17/-
7,228,065	10/-	Goodlass Wall & Lead Industries ...	37/9 —1/-	15	19L	3 19 6	44/9	34/9	41/9	33/-
696,780	10/-	Greenwood & Batley	27/3xcap —9d.	30‡	30	5 10 0	29/6	23/9Z	33/6	29/1½
792,000	5/-	Harrison (B'ham) Ord.	14/3 —3d.	*20‡	*17½	3 10 3	14/6	12/-	15/10½	11/9
150,000	1	Ditto Cum. Pref. 7%	20/3	7	7	6 18 3	20/4½	20/-	23/6	22/-
1,612,750	5/-	Heenan Group	16/3 —6d.	13	15	4 0 0	17/1½	10/6	13/-	9/10½
251,689,407	Stk. (£1)	Imperial Chemical Industries ...	78/6 +6d.	13½	11½	3 10 0	81/6	63/1½	76/6	54/-
34,736,773	Stk. (£1)	Ditto Cum. Pref. 5%	16/-	5	5	6 5 0	16/-	14/10½	18/-	15/4½
29,196,118	**	International Nickel	143½ —3	$1.60	$1.50	2 1 0	152½	104	105	84½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	14/- —6d.	5	5	7 2 9	14/10½	13/9	16/6	14/6
6,000,000	1	Ditto Ord.	62/3	12	12D	3 17 0	64/3	59/6	67/6	44/9
600,000	10/-	Keith, Blackman	21/- —3d.	17½	17½E	8 6 9	21/6	18/3	32/6	17/6
320,000	4/-	London Aluminium	14/4½	12	10	3 6 9	15/-	8/6	12/6	7/10½
765,012	1	McKechnie Bros. Ord.	68/- +3/-	17½F	15F	5 3 0	68/-	53/6	71/6	57/3
1,530,024	1	Ditto A. Ord.	67/- +2/9	17½F	15F	5 4 6	67/-	53/3	69/3	55/-
1,108,268	5/-	Manganese Bronze & Brass	16/-	20⅝	20⅝	6 10 0	18/6	14/-	18/6	13/4½
50,628	6/-	Ditto (7½% N.C. Pref.) ...	5/9	7½	7½	7 16 0	6/-	5/4½	6/6	5/9
26,361,444	Stk. (£1)	Metal Box	94/9	12M	13B	2 9 6	100/9	68/3	84/3	61/-
415,760	Stk. (2/-)	Metal Traders	8/6	50	50	11 15 3	8/7½	6/9	10/9	7/1½
160,000	1	Mint (The) Birmingham	43/-	12½	10	5 16 0	43/-	36/-	39/-	33/6
80,000	5	Ditto Pref. 6%	76/3	6	6	7 17 6	77/6	76/-	80/-	75/-
5,187,938	Stk. (£1)	Morgan Crucible A.	68/3 —1/-	13	12	3 16 3	71/3	53/4½	63/-	47/6
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref.	15/6	5½	5½	7 2 0	17/-	15/3	18/9	15/9
3,850,000	Stk. (£1)	Murex	50/6 +6d.	22½J	15	5 2 0	52/-	39/9	45/-	35/3
585,000	5/-	Ratcliffs (Great Bridge) Ord. ...	15/9	10	10R	3 3 6	16/6	15/9	17/-	14/9
195,000	5/-	Ditto 8% Max. Ord.	4/10½	8	—	8 4 0	5/-	4/10½	5/3	5/-
1,064,880	10/-	Sanderson Kayser	40/-	35‡	25	4 7 6	41/3	33/9	40/3	27/7½
3,400,500	Stk. (5/-)	Serck	18/10½xd +9d.	12½	17½GD	3 6 3	18/9	15/-	25/6	15/3
8,035,372	Stk. (£1)	Stone-Platt Industries	61/6	15	15	4 17 6	67/-	55/-	64/4½	52/3
2,928,963	Stk. (£1)	Ditto 5½% Cum. Pref.	15/6	5½	5½	7 2 0	18/-	15/-	18/7½	15/3
35,344,881	Stk. (£1)	Tube Investments Ord.	76/3 —3d.	14	20	3 13 6	85/6	72/3	140/3	63/10½
41,000,000	Stk. (£1)	Vickers	38/3 +6d.	10	10	5 4 6	38/3	28/-	39/7½	27/1½
750,000	Stk. (£1)	Ditto Pref 5%	14/6	5	5	6 18 0	15/-	12/7½	17/6	13/3
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	20/6	*5	*5	7 5 0A	21/1½	19/9	24/6	20/1½
4,594,418	1	Ward (Thos. W.) Ord.	83/- —1/6	13½	25	3 6 3	84/6	64/6	94/-	63/-
7,109,424	Stk. (£1)	Westinghouse Brake	45/6 —9d.	11	10	4 16 9	46/3	36/4½	60/6	37/6
323,773	2/-	Wolverhampton Die-Casting ...	11/9 —3d.	35	30	5 19 3	13/4½	9/-	13/10½	8/1½
591,000	5/-	Wolverhampton Metal	29/- +3d.	32½	27½	5 12 0	30/-	24/6	39/9	23/9
156,930	2/6	Wright, Bindley & Gell	4/7½	15	20‡	8 2 3	4/7½	3/7½	4/6	2/10½
124,140	1	Ditto Cum. Pref. 6%	13/3 —3d.	6	6	9 1 3	13/7½	13/6	15/-	13/6
150,000	1/-	Zinc Alloy Rust Proof	5/1½	40	30	7 16 3	5/6	4/6	5/4½	4/-

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting. **Shares of no Par Value. ‡ and 100% capitalized issue. *The figures given relate to the issue quoted in the third column. A Calculated on £7 8 9 gross. D and 50% capitalized issue. C paid out of Capital Profits. E and 50% capitalized issue in 7% 2nd Pref. Shares. R and 33⅓% capitalized issue in 8% Maximum Ordinary 5/- Stock Units. φ and 6½% from Capital Profits. B and 50% capitalized issue. G and 1½d. special distribution. F and special 5% tax free dividend. H As forecast. ¶And 3 for 7 capitalized issue. L and 33⅓% capitalized issue. M and 10% capitalized issue. J and 75% capitalized issue. S and 40% capitalized issue. O calculated at 13¾%. Interim on smaller capital. P Calculated at 11½%. Q also 1/- special tax free dividend and 50% capitalized issue. T Per £1 unit. Z After capital reorganization.

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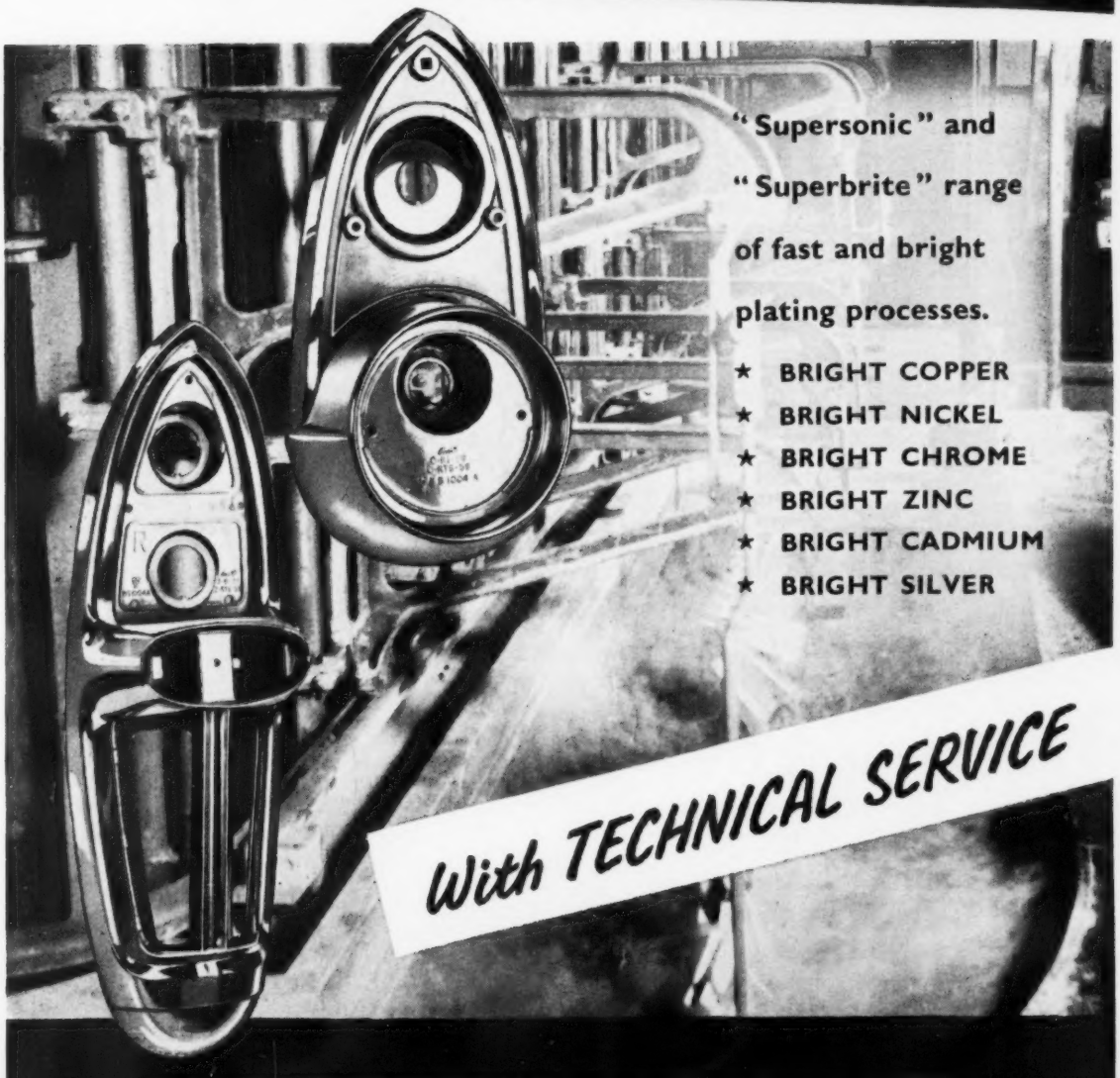

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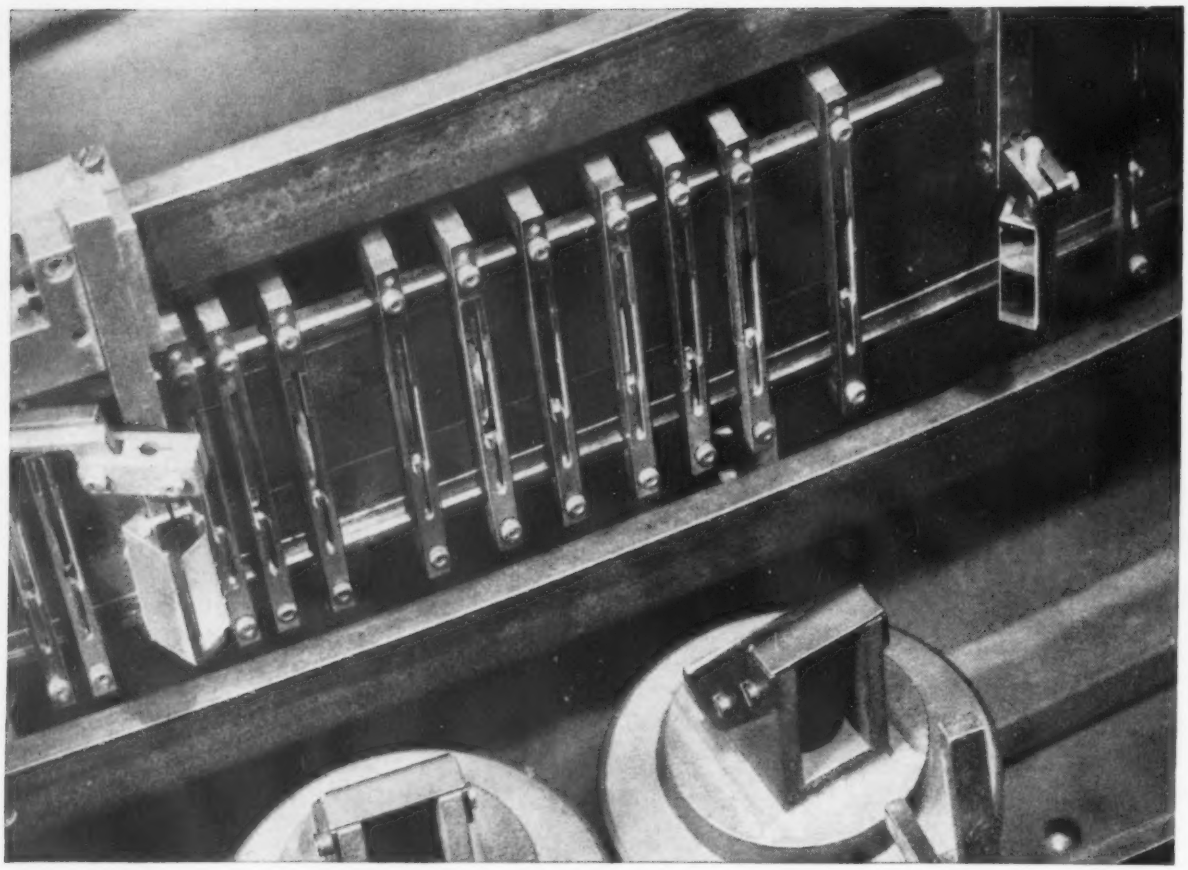

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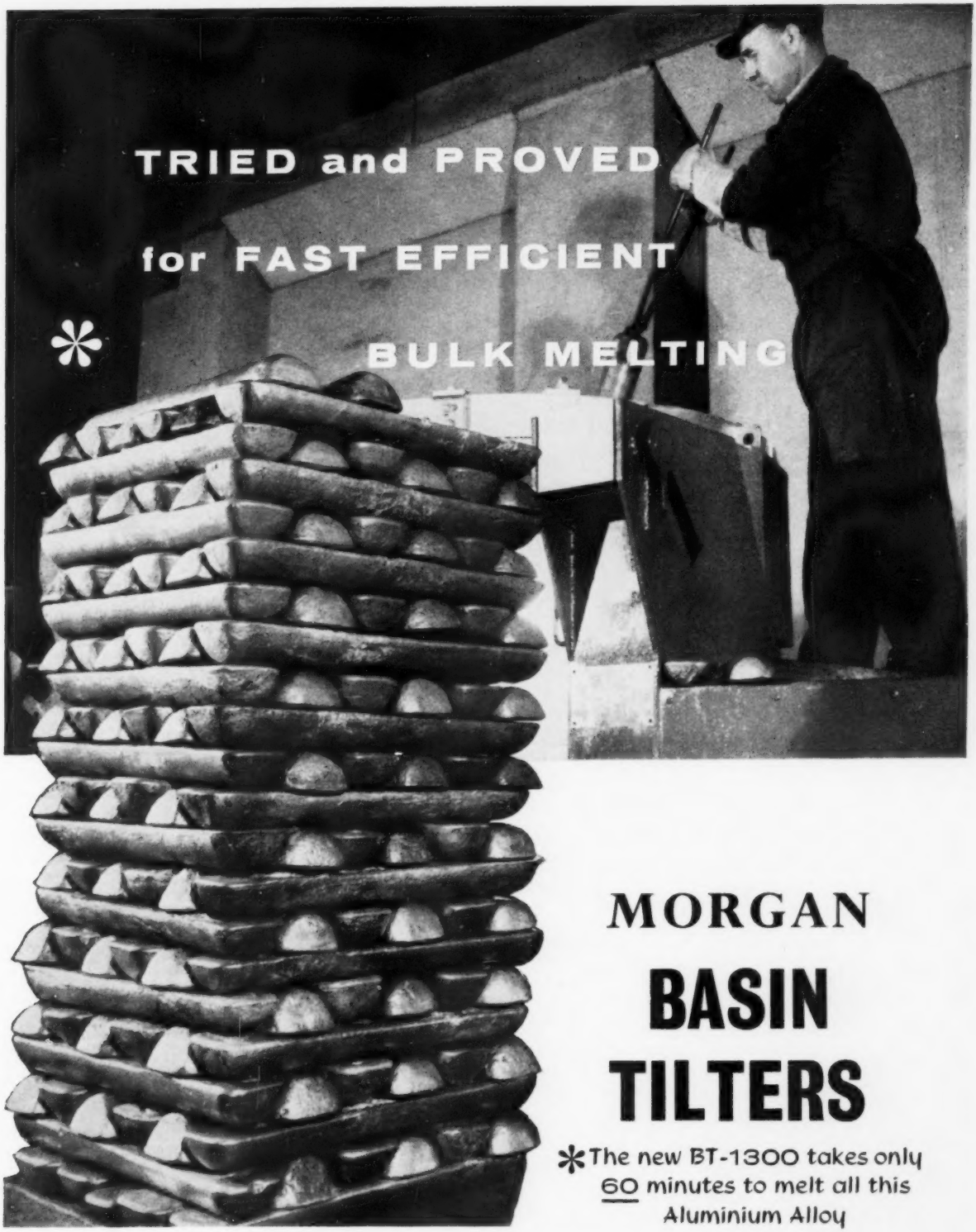

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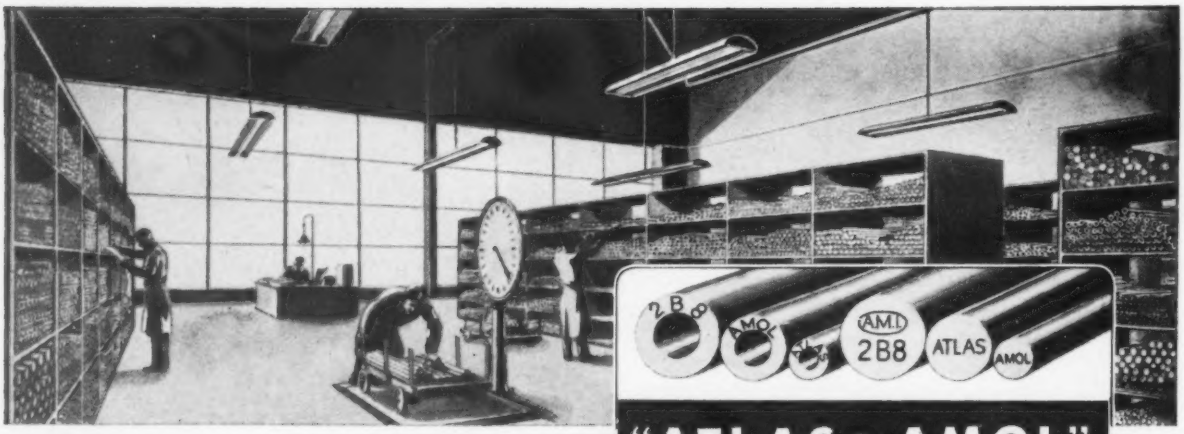

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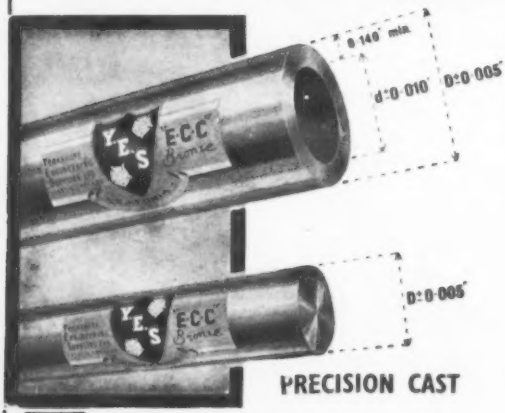

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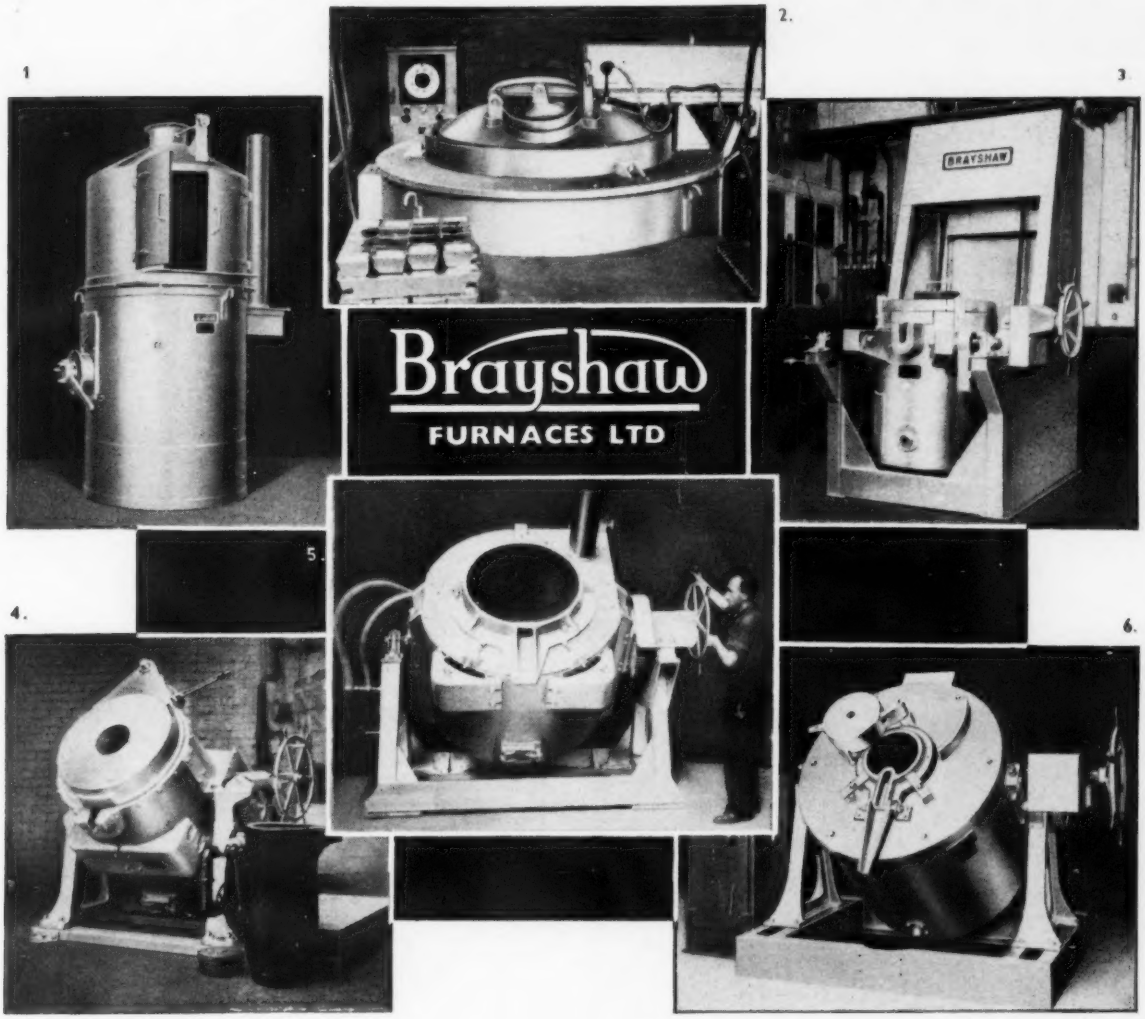

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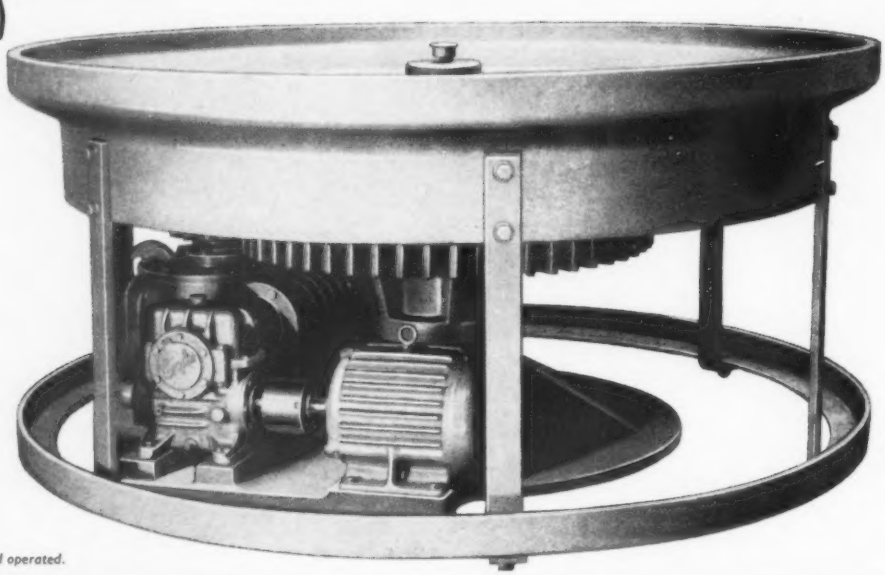

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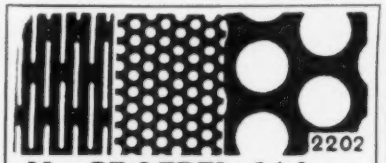

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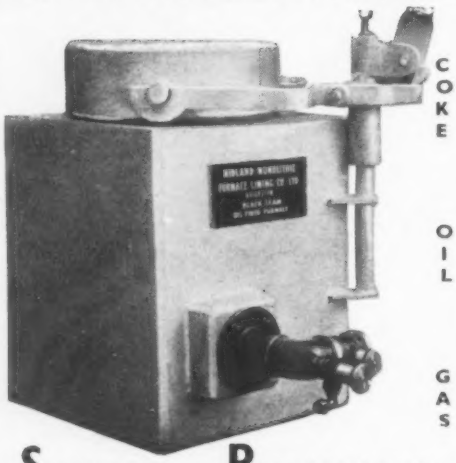

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